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VOL. 16, SEC. C. JULY, 1938 NUMBER 7

FRACTIONATION OF NITROGEN IN DEVELOPING WHEAT KERNELS[1]

BY A. G. MCCALLA[2]

Abstract

Total nitrogen in developing wheat kernels was fractionated to give non-protein nitrogen and three protein fractions. Each fraction was hydrolyzed and analyzed for amide and arginine nitrogen.

All fractions increased in amide and decreased in arginine nitrogen during kernel development. The main portion of the water-soluble protein is static in nature, and is considered to play no part in the metabolism of the endosperm proteins. The trend, with time, of amide in the two other protein fractions (soluble and insoluble in normal potassium iodide) was closely parallel to the trend of amide in non-protein nitrogen. The chemical nature of each of the gluten fractions in flour from the most insoluble to the most soluble is determined by the chemical nature of successive portions of the non-protein nitrogen in the wheat kernel at progressive stages of maturity.

Introduction

A considerable amount is known concerning the course of moisture, total nitrogen, and gross nitrogen fraction changes which take place during the development of grain, but little study has been made of the nature of the gross protein fractions, nor of the way in which the more complex proteins of the endosperm are formed.

Woodman and Engledow (9), Knowles and Watkin (3), and Teller (8) have all separated the total nitrogen of developing wheat kernels into non-protein and various protein fractions. Knowles and Watkin and Teller, however, dried their material before analyzing it, so the data obtained are not very useful in appraising metabolic changes. This criticism applies to other studies which have been carried out with wheat, and also to many made with other grains. Woodman and Engledow, however, worked with fresh material. They partitioned the non-protein nitrogen into various types of nitrogen compounds, but made only a gross separation of the protein fractions. No detailed analysis of these fractions was made.

Investigations carried on in this laboratory during the past few years have been concerned on the one hand with the total nitrogen and nitrogen fractions of developing wheat (4, 5), and on the other with fractionation of the protein

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Contribution from the Department of Field Crops, University of Alberta, Edmonton, with financial assistance from the National Research Council of Canada. Published as Paper No. 137 of the Associate Committee on Grain Research of the National Research Council and Dominion Department of Agriculture.

[2] *Research Assistant, Associate Committee on Grain Research, University of Alberta, Edmonton.*

making up the gluten of flour (6). The present study combines the basic methods of both lines of investigation, with the object of obtaining information as to the way and order in which the various nitrogen fractions are formed in the developing kernel.

Material and Methods

The experiments were carried out on material grown at Edmonton in the summer of 1935. Two varieties of hard red spring wheat, Reward and Red Bobs, were grown side by side in one-tenth acre plots. When the lower florets were in full flower, 3,500 heads of each variety at the same stage of development were tagged. There was a difference of two days in the time of tagging the two varieties. On July 26, eight and ten days after tagging, the first collection was made. The heads were taken to the laboratory where approximately 300 of each variety were threshed out. The fresh kernels were used as soon as possible for the various determinations. Collections were made twice a week until development of the grain was complete. Fewer heads were collected at later dates, the number falling to approximately 100 at maturity.

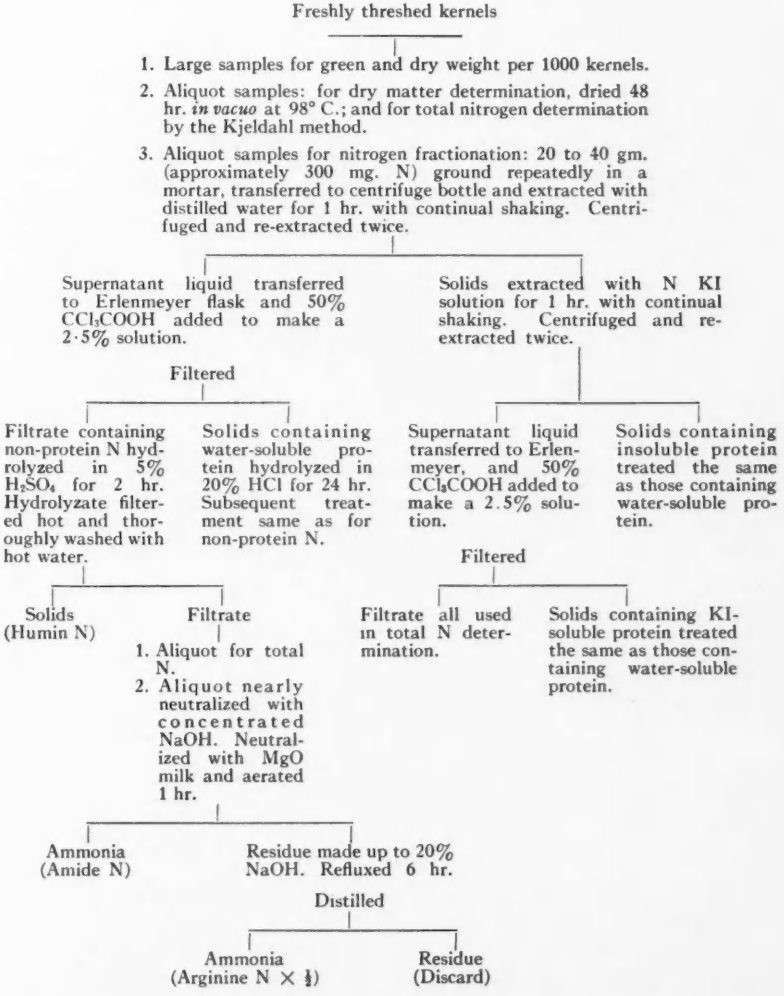
The general plan of analysis is presented in outline on the opposite page.

Grinding of the fresh kernels was relatively easy to accomplish until the dry matter content reached 45 to 50%, but became increasingly difficult with maturity. All collections of Red Bobs were satisfactorily ground and extracted, but a few of the more mature Reward samples yielded too high values for the KI-insoluble nitrogen. The difference was due to the harder, more vitreous texture of the Reward kernels, which made disintegration much more difficult.

Normal potassium iodide was used as an extraction solution for several reasons. Many other substances have been used for extracting wheat proteins, but only two seemed to warrant serious consideration. These were sodium salicylate solution, which is an excellent dispersing agent for gluten, and a combination of dilute salt solutions followed by alcohol. The use of sodium salicylate presented technical difficulties which were almost impossible to overcome. Complete precipitation of the protein dispersed cannot be secured with salts, and acid precipitants bring down salicylic acid. Furthermore, this reagent disperses some of the starch to a jelly-like mass which cannot be centrifuged or filtered off. Salts other than potassium iodide dispersed too little of the protein remaining after water extraction. When dilute salt solution was followed by 70% alcohol, the resultant extract was much more difficult to handle than that obtained with normal potassium iodide. The latter dispersed approximately 50% of the protein remaining after water extraction of the ground wheat, and appeared to be the most generally satisfactory reagent to use.

After precipitation of the KI-soluble protein, small amounts of nitrogen remained in the filtrate. These were determined and are included as KI-soluble. At no time after the kernels were well formed did this nitrogen make up more than 5% of the fraction.

SCHEME OF ANALYSIS


Freshly threshed kernels
1. Large samples for green and dry weight per 1000 kernels.
2. Aliquot samples: for dry matter determination, dried 48 hr. *in vacuo* at 98° C.; and for total nitrogen determination by the Kjeldahl method.
3. Aliquot samples for nitrogen fractionation: 20 to 40 gm. (approximately 300 mg. N) ground repeatedly in a mortar, transferred to centrifuge bottle and extracted with distilled water for 1 hr. with continual shaking. Centrifuged and re-extracted twice.
Supernatant liquid transferred to Erlenmeyer flask and 50% CCl_3COOH added to make a 2·5% solution.
Solids extracted with N KI solution for 1 hr. with continual shaking. Centrifuged and re-extracted twice.
Filtered
Filtrate containing non-protein N hydrolyzed in 5% H_2SO_4 for 2 hr. Hydrolyzate filtered hot and thoroughly washed with hot water.
Solids containing water-soluble protein hydrolyzed in 20% HCl for 24 hr. Subsequent treatment same as for non-protein N.
Supernatant liquid transferred to Erlenmeyer, and 50% CCl_3COOH added to make a 2.5% solution.
Solids containing insoluble protein treated the same as those containing water-soluble protein.
Filtered
Solids (Humin N)
Filtrate
1. Aliquot for total N.
2. Aliquot nearly neutralized with concentrated NaOH. Neutralized with MgO milk and aerated 1 hr.
Filtrate all used in total N determination.
Solids containing KI-soluble protein treated the same as those containing water-soluble protein.
Ammonia (Amide N)
Residue made up to 20% NaOH. Refluxed 6 hr.
Distilled
Ammonia (Arginine N × ½)
Residue (Discard)

The hydrolysis of the KI-insoluble fraction in the presence of large quantities of carbohydrates results in the formation of relatively high amounts of humin. While this humin formation may reduce the arginine values, it has been shown that the ammonia set free by hydrolysis of the amide groups is not affected (2). The amide values, therefore, are probably quite reliable.

Other details or references for individual methods of determination are given in an earlier paper (4).

Results

The results of dry matter and total nitrogen determinations are not presented since they add nothing to the results and conclusions of earlier studies (5, 9). Percentage dry matter is used throughout this paper as a measure of maturity, since the critical changes in metabolism have been found to be associated with definite levels of dry matter content.

In the discussion, all results for any single determination are treated as a unit, regardless of the variety of wheat. In so far as the main conclusions are concerned, the two varieties behaved alike. Any differences which were found are associated with the differences in general level of protein content, Reward being at all stages appreciably higher than Red Bobs. Since Reward was more difficult to grind than Red Bobs, the values for the quantities of the various fractions extracted are not as reliable for this variety.

Nitrogen Fractions

The results of the nitrogen fractionation are presented in Table I and Fig. 1.

TABLE I

Nitrogen fractions as % of total nitrogen in developing wheat

Dry matter content, %		Non-protein nitrogen, %		Water-soluble protein nitrogen, %		KI-soluble protein nitrogen, %		KI-insoluble protein nitrogen, %	
Reward	Red Bobs	Reward	Red Bobs	Reward	Red Bobs	Reward	Red Bobs	Reward	Red Bobs
25.8	25.2	31.1	37.5	36.4	31.5	—	—	—	—
28.8	26.8	27.6	35.6	34.4	35.7	17.7	12.8	19.6	16.0
32.5	29.9	22.8	29.7	31.4	36.4	20.8	16.1	26.4	21.4
38.0	35.0	—	—	27.4	33.8	24.8	22.6	32.8	26.0
41.4	39.3	14.8	18.0	20.9	28.3	29.0	26.2	37.5	26.0
44.7	43.2	14.6	16.9	15.2	22.5	28.3	28.3	38.9	31.8
47.0	46.9	11.9	13.1	13.8	15.6	27.3	31.1	46.2	40.6
50.6	48.8	9.4	9.8	14.3	15.5	32.3	33.7	44.3	44.2
53.8	52.5	7.8	8.9	11.6	13.0	35.1	36.7	44.6	38.6
56.0	56.1	6.5	7.3	10.7	10.2	32.8	41.0	48.2	41.0
62.4	58.8	7.8	6.8	10.1	7.6	40.1	42.2	40.0	43.3

Both the precentages and total weights of non-protein and water-soluble protein nitrogen agree with values presented by Woodman and Engledow (9) and McCalla and Newton (5). The water-soluble protein is, of course, extracted with a dilute salt solution, since the grain contains appreciable amounts of salts.

The protein soluble in normal potassium iodide formed slightly less than half that remaining after extraction with water. The amount of this fraction increased most rapidly after the wheat reached a dry matter content of about 45%.

The protein insoluble in normal potassium iodide is the least definite fraction of all those studied. It consists of that part of the endosperm protein

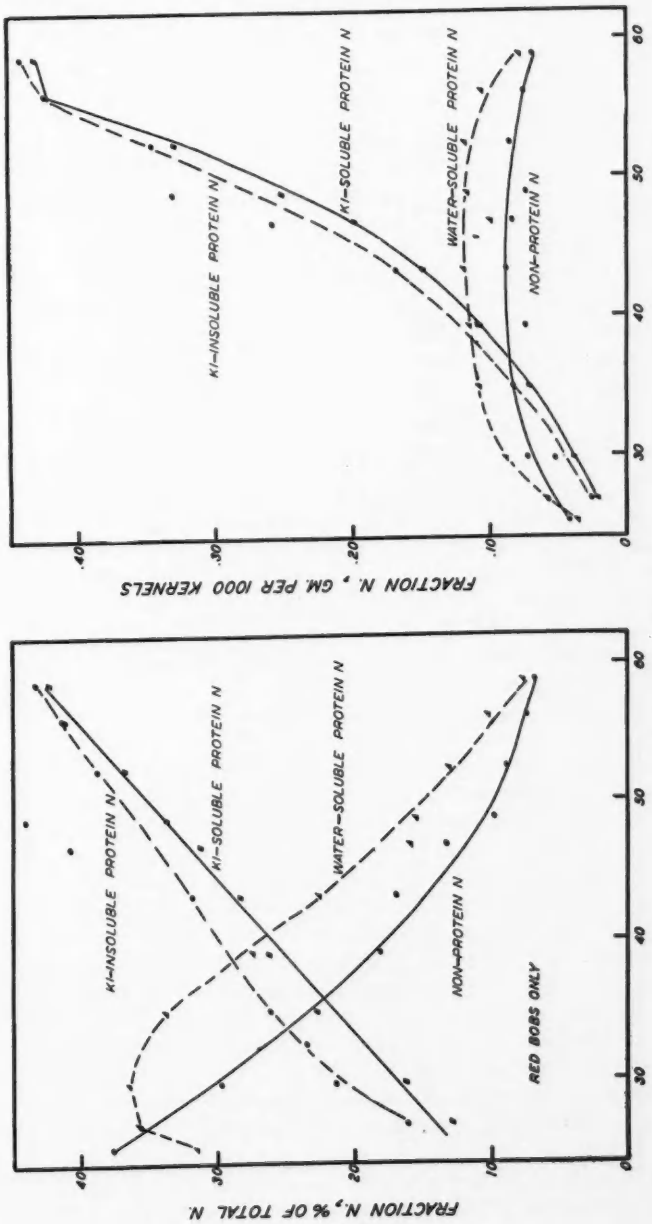


FIG. 1. *The distribution of nitrogen fractions in developing kernels of Red Bobs wheat.*

which is insoluble in this reagent, plus the relatively insoluble proteins of the bran layers and structural units, plus any amount of the other fractions remaining as a result of incomplete extraction. Nevertheless, the general course of the results shows that there was a fairly regular increase in this fraction with maturity, and the increase was certainly largely the result of an increase in the more insoluble fractions of the gluten protein. The two points (Fig. 1) which fall off the general curve were obtained with inadequately ground wheat. When precautions were taken to insure reasonably complete extraction of the more soluble fractions, no such discrepancies occurred. The part of this fraction contained in the bran and other structural material is largely developed at an early stage, and if allowance is made for a constant quantity throughout development of the grain, the values for, but not the course of, the results would be slightly altered.

The curves in the second part of Fig. 1 are very similar to those presented by Bishop and Marx (1) for the proteins of barley.

Analyses of Nitrogen Fractions

Each of the fractions was hydrolyzed and analyzed for amide and arginine nitrogen. The results are presented in Fig. 2.

The accuracy with which amide nitrogen can be determined makes all the values reliable. The experimental error of the arginine determination is, however, much greater, with the result that the values obtained for the non-protein nitrogen fraction are meaningless. The results for the other fractions are much better, but are not as reliable as those for amide. For this reason the general discussion centres around the amide results, although definite trends in arginine exist for each protein fraction. These results, while inadequate in themselves, support the conclusions reached on the basis of the amide data.

There were marked differences in the amide values obtained for the four fractions, and in the changes in the proportion of amide during maturation of the grain. There was, however, a very definite and regular change with each fraction.

Osborne (7) concluded that the albumin and globulin of wheat are contained chiefly in the embryo, while the gluten proteins make up most of the protein material found in the endosperm. Woodman and Engledow (9) extended this conclusion, as a result of finding that the gluten proteins accumulated continuously with maturity, but the embryo proteins, to which the NaCl-soluble protein of their study chiefly belonged, did not. They raised the question as to whether these embryo proteins functioned as precursors of the gluten proteins, but did not speculate on this point.

The results of the present study seem to offer at least a tentative answer to this question. Since the amide content of the water-soluble protein changed less with maturity than that of any other fraction, and since the level of amide content was at all stages of maturity much lower than that of either the non-protein nitrogen or the more insoluble protein fractions, it would appear

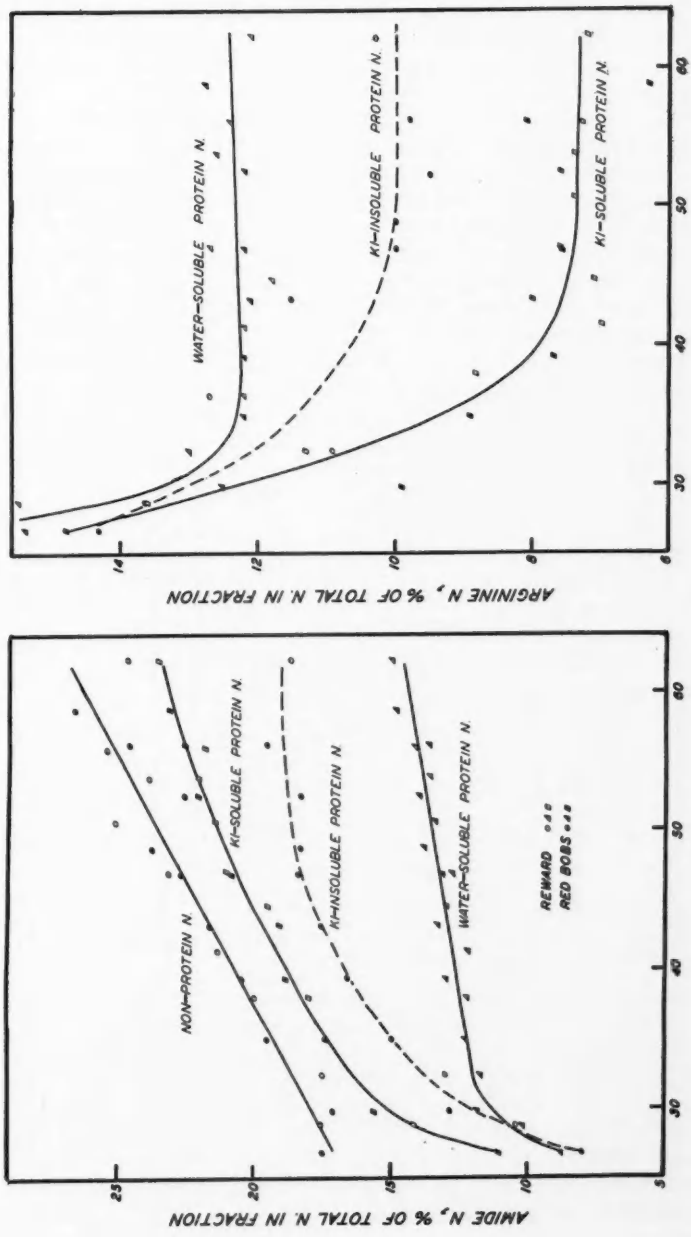


FIG. 2. *Amide and arginine nitrogen in the various nitrogen fractions of developing wheat.*

that at least the main portion of this water-soluble protein is not active in metabolism. If this view is correct, then production of the endosperm proteins must take place directly through the condensation of the compounds making up the non-protein nitrogen.

While the main portion of the water-soluble protein is thus considered to be static in nature, there must be a small portion of this fraction involved in metabolism, since condensation of the soluble non-protein compounds to the relatively insoluble endosperm proteins must take place through a protein fraction intermediate in solubility. This small labile portion of the water-soluble protein should show the same gradual increase in amide nitrogen as exhibited by the other fractions, with progressive maturity. Since this protein is an intermediate step in the metabolism of the main endosperm proteins, the amide content would be intermediate between that of the non-protein nitrogen and that of the KI-soluble fraction; and the presence of small quantities of this protein should cause an increase in amide content of

TABLE II

MIDPOINTS OF FRACTIONS FOR FIG. 3

Dry matter at time of collection, %	Non-protein N*			Gluten N, Flour 2**			
	Mg. N per 1000 kernels	Total mg. N per 1000 kernels	Midpoint of fraction, %	Fraction	Per cent of total dispersed N	Per cent of dispersed gluten N†	Midpoint of fraction, %
25.6	45	45	2.8	1	1.6	1.8	0.9
27.8	60	105	9.4	2	23.4	26.7	15.2
31.2	71	176	18.1	3	15.1	17.2	37.1
36.5	58	234	25.7	4	16.6	18.9	55.1
40.4	73	307	34.0	5	10.1	11.5	70.4
44.0	90	397	44.2	6	13.3	15.2	83.7
47.0	87	484	55.2	7	7.6	8.7	95.7
49.7	80	564	65.7				
53.2	80	644	75.8				
56.0	73	717	85.4				
60.6	80	797	95.0				

* *Mean values for Reward and Red Bobs.*

** *Original data obtained by McCalla and Rose (6), results for only one replicate presented here.*

† *Recalculated from the data in the preceding column, with the assumption that soluble N fractions with low amide values do not belong to the gluten complex.*

the water-soluble fraction with progressive maturity. This increase occurs (Fig. 2), and its magnitude supports the hypothesis that the water-soluble protein is made up of a main static portion which does not change with maturity and a small labile portion which is active in metabolism. Since the range of solubility of these two portions is the same, it is doubtful if the hypothesis can be directly proved.

The amide values for the non-protein nitrogen, on the other hand, indicate a close parallelism between the changes in this fraction and those in the KI-soluble and KI-insoluble protein fractions. The transformation of the non-

protein nitrogen is believed to take place directly to the most soluble fraction of the gluten protein (the small labile portion of the water-soluble fraction), which in turn becomes less soluble. As the kernel fills, there is a continual condensation of non-protein nitrogen to form the endosperm proteins, and a progressive loss in solubility of the protein already formed.

The amide values for non-protein nitrogen have been replotted in Fig. 3 against the midpoints of the non-protein fraction of the successive collections (see Table II). The total quantity of this fraction, assuming that different

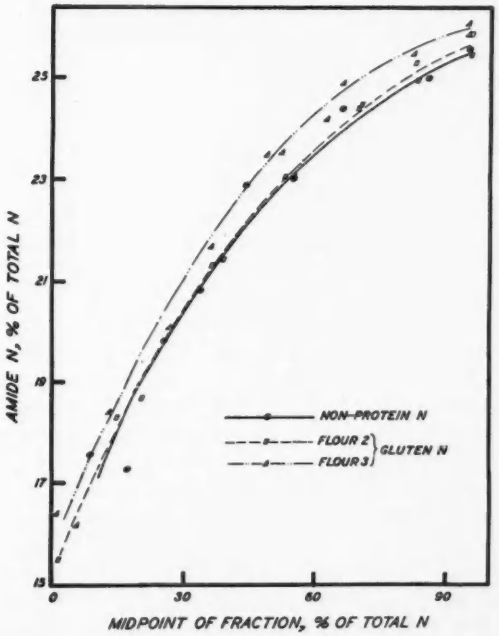


FIG. 3. *Comparison of the amide content of the non-protein nitrogen fraction of wheat at progressive stages of maturity with the amide content of successive gluten fractions of mature wheat.*

portions of the total were determined at each collection, was 797 mg. per 1000 kernels (average for the two varieties). This accounted for 89% of the total KI-soluble and -insoluble nitrogen, all of which must have passed through the non-protein nitrogen stage. The amount not determined was undoubtedly distributed among the various collections, and hence would affect the total quantity but not the trend of the cumulative curve.

With the values for the non-protein nitrogen in Fig. 3 have been plotted the amide values for gluten nitrogen fractions as determined by McCalla

and Rose (6). The amounts of nitrogen in each fraction and the midpoints used in Fig. 3 are given in Table II.*

The agreement between the amide curves for the non-protein nitrogen in developing kernels and for the protein fractions of gluten is remarkably close. It seems probable that the amide content of the least soluble gluten protein is relatively low because this fraction is derived from the non-protein nitrogen present in the kernel at an early stage in the filling process, while the amide content of the most soluble gluten is high because this fraction is derived from the non-protein nitrogen present just before maturity. Similarly, the chemical nature of the intermediate gluten fractions is determined by the chemical nature of corresponding non-protein nitrogen at intermediate stages of maturity.

On the basis of these results the general process of endosperm protein formation may be represented as follows: when filling of the kernel starts, the non-protein nitrogen translocated from the vegetative parts is condensed through a labile water-soluble protein stage to the true endosperm or gluten proteins. As the kernel fills, non-protein nitrogen is continually condensed to form endosperm protein, and the protein already formed gradually loses solubility. Two general effects result from this condensation and decrease in solubility. First, the earliest-formed gluten fractions become the most insoluble portion of the protein in the mature kernel, while the solubility of the later-formed fractions is dependent upon the stage at which these are formed, the last formed being the most soluble. Second, the non-protein nitrogen in the kernel at any one stage of development is the precursor of a definite fraction of the endosperm protein, rather than of a portion of whole gluten complex.

If this hypothesis is correct, the various fractions which make up the gluten of mature wheat would not all be present until the grain is almost fully developed. Chemical development of kernels is practically complete when the dry matter content reaches 58%, and Woodman and Engledow (9) obtained the first tenacious gluten mat at a dry matter content of 55%, and McCalla and Newton (5) obtained it at 56%. The results of the present study agree. Woodman and Engledow concluded that a definite amount of glutenin was necessary before gluten could be formed, since the amount of this most insoluble fraction was low in those collections from which no gluten mat could be obtained. Fractionation studies with gluten show that the presence of the more insoluble fractions is necessary for the formation of a tenacious mass. The results of the present experiment therefore indicate that these more insoluble fractions do not reach the physical state found in the mature kernel until the grain is almost fully developed, although the chemical composition of the fractions is apparently determined at the time that the non-protein nitrogen is condensed to protein.

* *In the work from which these data are taken, it was found that approximately 88% of the gluten nitrogen belonged to a fractionable complex which increased systematically in amide content with increasing solubility. The remainder of the protein was quite distinct in composition, and obviously did not belong to the main gluten complex. The data used in Fig. 3 were recalculated on the assumption that 88% of the dispersed nitrogen makes up the true gluten protein, while the remainder is of the same nature as the static water-soluble protein of the present study.*

One further fact which agrees with the results presented in this paper was recorded in earlier work (4). During the filling of the grain there is a rapid hydrolysis of the protein of the vegetative parts of the plant. The non-protein nitrogen formed by this hydrolysis increased in amide content with time. Since this non-protein nitrogen was translocated to the kernels as fast as it was formed, successive portions of this translocated material were progressively higher in amide. This is reflected in the present study by the increase, with time, of the amide content of the non-protein nitrogen fraction of the kernels.

Further fractionation studies of the nitrogen of developing wheat kernels are planned. Separation of the gluten protein into more numerous fractions should yield more direct evidence as to the validity of the general conclusions presented in this paper.

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CONIOSPORIUM DISEASE OF APPLES AND CRAB-APPLES[1]

By John Dearness[2] and W. R. Foster[3]

Abstract

A new species of Coniosporium—*C. Mali*—parasitic on the crab-apple and several varieties of the common apple, is described. The symptoms of the disease, both on the foliage and the fruit, are similar to those produced by *Fusicladium dendriticum*. Therefore, Coniosporium scab is suggested as the common name.

Introduction

In the spring of 1937, Mr. W. H. Robertson, Provincial Horticulturist for British Columbia, directed the attention of the junior writer to what appeared to be a new disease on crab-apple leaves. A survey of the most important fruit districts on Vancouver Island showed that the disease was general not only on crab-apples but also on many varieties of the common apple. One crab-apple tree observed had lost over 75% of its leaves. Defoliation was less severe in apples, hardly reaching 10% in any tree. Owing to the simultaneous presence of Fusicladium scab on the fruit, it was difficult to estimate the damage caused by the newly-described disease, for which the name Coniosporium scab is suggested.

Description of the Fungus

Coniosporium Mali Dearness & Foster sp. nov.—Parasitic on leaves, petioles and fruit of the apple, *Pyrus Malus* L. (*Malus Malus* (L.) Britton).

Discolorations of the green leaf tissue begin as small grayish-brown spots on the veins and veinlets and extending along them, usually branching more or less from them in a dendriform manner (Fig. 2), and becoming almost black with the development of the layer of spores, sometimes darkening the whole upper surface of the leaf (Fig. 1); usually indistinct on the lower surface. On the fruit (Fig. 3), the small scattered acervuli become confluent under the grayish cuticle which is broken into scales and thrown off, producing a scab over the shrunken and cracked pulp, very similar to the scab of *Fusicladium dendriticum* (Wallr.) Fckl. (*Venturia inaequalis* (Cke.) Wint. in its mature stage).

The conidia are olivaceous, seeming sessile or on short, 3 to 13 (20) × 3 μ, fertile, brown hyphae, rounded or truncate above, tapering downward, often somewhat narrowed near the middle so as to appear slipper-shaped, usually guttate, quite various in shape and size, 13 to 20 × 3.3 to 8 μ, average about 14.9 × 5 μ (Fig. 4).

Coniosporium Piri Oudemans on the pear, *Pyrus communis*, is said (1, 3) to have spores 16 μ wide and to be nearly globose. The shape and size of the

[1] *Manuscript received November 25, 1937.*
Contribution from the Plant Pathology Branch, Provincial Department of Agriculture, Saanichton, British Columbia.
[2] *Mycologist, London, Ontario.*
[3] *Assistant Plant Pathologist, British Columbia Department of Agriculture.*

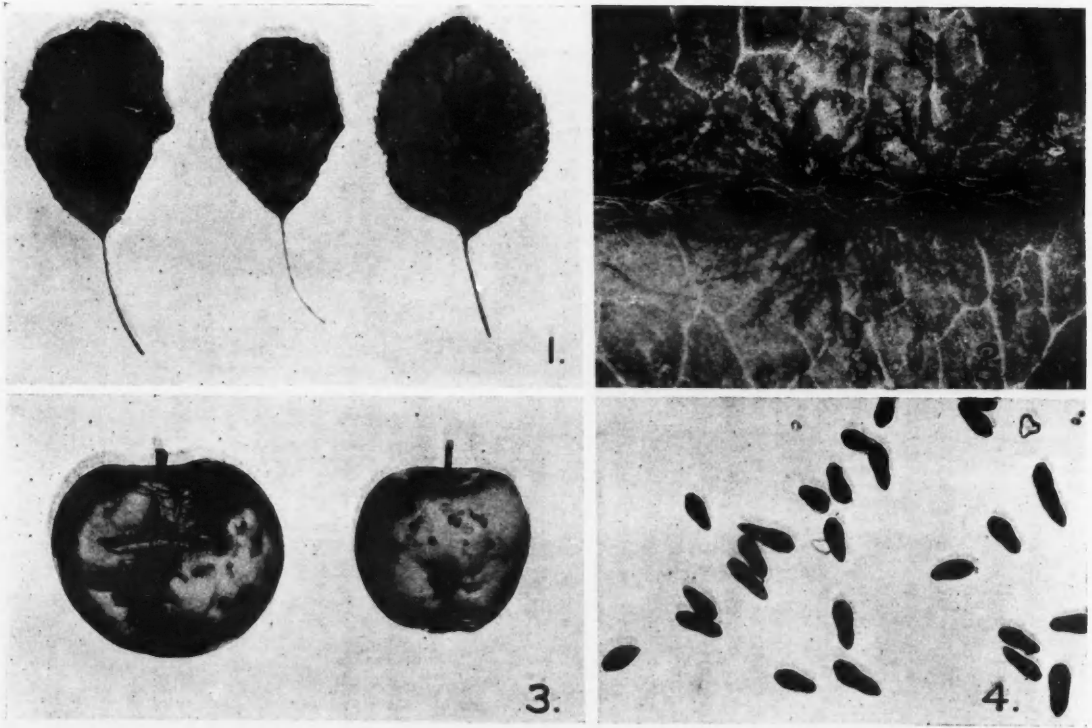

FIG. 1–4. *Coniosporium Mali.* 1. *On apple leaves; somewhat reduced.* 2. *On midvein and veinlets; 8×.* 3. *On fruit; somewhat reduced.* 4. *Conidia; nearly 400×.*

spores of *Coniosporium Rosae* Brun. (2) are not markedly different; it inhabits, however, dead stems of rose and in the description is not said to be parasitic. (D. No. 8894.)

Parasiticum; *Fusicladium dendriticum* simulans.

Hab. in foliis viventibus, petiolis et fructu *Piri Mali* L.

Maculis in foliis primitus griseo-brunneis, deinde paene atris, plerumque superioribus, denique confluentibus, interdum tota folia infuscantibus.

Conidiis olivaceis, constipantibus, sessilibus vel in verticibus hypharum fertilium, brevium, fuscarum, oblongis vel sandaleis, diversis in forma et mensura, 13 ad 20 × 3.3 ad 8 μ, plus minusve 14.9 × 5 μ. Hyphae fertiles 3 ad 13 (20) × 3 μ.

Hosts and Distribution

The effects of *Coniosporium Mali* were observed in nearly every apple orchard examined in Sooke, Victoria, Sidney, Duncan, Ladysmith, and Nanaimo districts on Vancouver Island and at one place at Armstrong in the northern Okanagan valley. It was noticeably injurious on crab-apples, on the orchard varieties—Grimes Golden, McIntosh Red, and Vanderpool Red, and present but less injurious on Alexander, Bismarck, Duchess, King, Oldenburg, Salome, Wealthy, and Yellow Newton.

Control

An attempt will be made to complete the life history. The part known, however, is so much like that of the common Fusicladium scab that in all probability the same treatment can be advised for both.

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PHYSICAL PROPERTIES OF MINERAL SOILS OF QUEBEC[1]

PART I. CULTIVATED SOILS

By W. Rowles[2]

Abstract

The relation between texture of soils of Missisquoi and Brome Counties and the growth of alfalfa thereon is examined. It is shown that soils on which alfalfa thrives contain relatively more coarser soil particles. The effect of treatment with lime upon the rate of evaporation of water from the soil, moisture equivalent, heat of wetting, volume weight under field conditions, volume weight of laboratory samples, pore space, moisture content of saturated soil, volume expansion upon wetting, and resistance of the soil to penetration is investigated. Treatment with lime produces a significant effect upon several of these properties. New apparatus is described to measure the volume weight of soil *in situ* and to measure the resistance of the soil to penetration.

Introduction

Although a considerable amount has been written concerning the chemical and biological condition of Quebec soils (11–15), very little has been published of their physical properties. During the past few years a number of studies have been made at this laboratory of the more important physical properties of a group of mineral soils of this province. Most of the work has been done as part of a co-operative study carried on by the Macdonald College Soil Fertility Committee in which the Departments of Agronomy, Bacteriology, Chemistry, and Plant Pathology have also collaborated. As may be noted in the following account, the direction of the physical approach has been influenced, to some extent, by the results obtained by the other departments. The earlier studies were made prior to the acceptance of the present method of mechanical analysis and were concerned entirely with cultivated soils; the later work, described in Part II, was confined to virgin soil.

Experimental Methods and Results

A. Mechanical Analyses

One of the first problems attacked was the inability to grow alfalfa on certain soils in the counties of Missisquoi and Brome. A number of fields were chosen in some of which alfalfa was successfully grown, while in the others all attempts had resulted in partial or total failure. The former were classed as "good" soils, the latter as "poor". Soil samples were taken from these fields as well as from a number of other representative fields of this district, and along with other observations, mechanical analyses were made of both surface and subsoil samples by the pipette method (1). The results are included in Table I.

[1] *Manuscript received May 2, 1938.*

Contribution from the Department of Physics, Faculty of Agriculture of McGill University, Macdonald College, Que., Canada. Journal Series No. 98.

[2] *Associate Professor of Physics, Macdonald College.*

TABLE I

MECHANICAL ANALYSIS OF SOILS FROM MISSISQUOI AND BROME COUNTIES

The separates are made on the American system of particle sizes and the percentages are expressed on the basis of ignited soil. Samples No. 1–6 and 13 are good alfalfa soils; 7-12 and 14 are soils on which alfalfa grows poorly or not at all. Surface and subsoils are indicated by the letters *a* and *b* respectively.

Sample	Stones	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Loss on solution	Loss on ignition	Total excluding stones
1a	21.4	5.9	7.9	23.4	11.1	4.3	14.4	19.7	1.5	11.3	99.5
1b	44.3	7.4	11.7	27.6	13.4	6.5	11.9	14.5	1.3	7.2	101.5
2a	6.0	3.8	2.3	5.9	9.0	11.1	21.8	25.0	2.5	17.5	98.9
2b	12.8	11.6	2.5	7.3	13.2	17.2	26.1	17.8	0.7	3.2	99.6
3a	15.8	6.5	7.9	22.2	9.3	3.1	18.1	21.7	1.3	10.6	100.7
3b	44.4	10.3	11.8	30.6	11.7	5.8	12.5	11.8	0.6	5.8	100.7
4a	6.2	18.3	3.8	8.8	10.1	10.5	20.5	18.4	1.1	7.7	99.2
4b	6.6	9.1	1.5	4.3	9.6	12.2	26.6	29.5	1.1	5.4	99.3
5a	30.2	18.2	12.1	8.1	4.3	7.0	17.5	15.6	2.1	14.9	99.8
5b	49.8	17.6	22.3	13.3	5.9	7.8	16.4	8.8	1.3	7.5	100.9
6a	19.0	16.1	11.4	20.0	10.4	6.7	16.5	7.6	1.5	9.0	99.2
6b	28.2	14.5	14.8	26.5	14.2	5.3	12.2	4.8	1.3	5.6	99.2
7a	12.7	7.6	2.2	4.8	7.1	11.4	38.3	14.0	2.1	12.7	100.2
7b	22.2	10.3	2.0	4.7	6.9	12.4	24.6	32.2	1.5	5.5	100.1
8a	1.3	0.4	0.6	2.4	17.3	30.5	27.5	4.8	2.4	13.7	99.6
8b	1.3	0.8	0.3	1.8	18.4	39.3	30.6	2.9	1.6	4.2	99.9
9a	4.2	1.1	0.4	1.0	6.7	23.8	40.4	10.1	2.9	13.0	99.4
9b	2.7	0.6	0.3	1.0	10.6	29.6	42.2	9.7	1.8	4.1	99.9
10a	16.2	3.2	1.7	3.6	7.0	17.9	37.8	11.2	2.8	15.5	100.7
10b	14.4	2.7	2.7	5.5	10.5	19.4	44.2	7.2	1.1	7.5	100.8
11a	35.6	6.5	5.7	12.8	16.0	14.3	22.6	11.5	1.8	10.7	101.9
11b	40.5	8.3	8.8	17.0	19.6	15.6	16.2	7.6	1.3	5.7	100.1
12a	23.8	4.1	4.5	6.9	11.7	15.0	27.6	14.4	2.8	12.9	99.9
12b	34.2	3.5	3.4	7.2	12.8	23.6	30.7	12.1	1.5	6.0	100.8
13a	34.0	7.6	7.1	10.9	12.4	8.5	23.4	10.7	3.3	16.1	100.0
13b	51.3	7.5	7.5	11.4	12.6	9.8	23.4	8.8	4.1	14.6	99.7
14a	54.6	4.7	5.5	10.8	9.6	9.7	27.8	15.4	1.6	14.0	99.1
14b	64.8	4.9	6.5	13.3	12.7	13.1	26.2	12.8	1.7	10.0	101.2
15a	9.0	5.7	5.7	15.1	18.6	18.9	18.2	6.5	2.4	8.9	100.0
15b	20.1	4.8	7.6	15.9	21.8	23.0	14.8	4.5	1.9	5.8	100.1
16a	2.2	2.8	4.3	18.4	29.3	14.8	13.1	7.1	1.7	8.4	99.9
16b	1.6	3.2	3.8	19.6	27.7	22.1	14.1	3.4	1.5	4.5	99.9

To compare the relative texture of the good and poor alfalfa soils Table II as been prepared; this shows, in the appropriate columns, the differences between the amounts of the various separates in the good and poor soils, together with their standard errors. By reference to Fisher's *t* table (5) the differences have been tested for significance. It is seen that the good soils contain a larger percentage of fine gravel, coarse and medium sand, and much less very fine sand and silt in the surface layers. In the subsoil a difference is again evident, there being significantly more fine gravel and less very fine sand and silt in the soils on which alfalfa thrives. While this is an important factor in the problem, there are, no doubt, other contributing causes which should be considered.

TABLE II

COMPARISON OF TEXTURE OF GOOD AND POOR SOILS

Significant differences ($P = 0.05$, $t > 2.45$) are marked *; highly significant differences ($P = 0.01$, $t > 3.71$) are marked **.

	Surface soils				Subsoils			
	Good soil (mean of 7)	Poor soil (mean of 7)	Difference between means	t	Good soil (mean of 7)	Poor soil (mean of 7)	Difference between means	t
Stones	18.90	21.20	2.30±8.2	0.36	33.91	25.73	8.18±11.0	0.74
Fine gravel	10.91	3.94	6.97±2.60	2.68*	11.14	4.43	6.71±1.99	3.37*
Coarse sand	7.64	2.94	4.70±1.60	2.94*	10.30	3.43	6.87±2.99	2.30
Medium sand	14.19	6.04	8.15±3.31	2.46*	17.29	7.21	10.08±4.62	2.18
Fine sand	9.51	10.77	1.26±1.92	0.65	11.40	13.10	1.70±2.09	0.81
Very fine sand	7.31	17.51	10.20±3.00	3.40*	9.23	21.86	12.63±4.04	3.13*
Silt	18.90	31.71	12.81±2.88	4.55**	18.44	30.67	12.23±4.51	2.71*
Clay	16.96	11.63	5.33±2.69	1.98	13.71	12.07	1.64±4.72	0.35
Loss on ignition	12.44	13.21	0.77±1.52	0.51	7.04	6.14	0.90±1.58	0.57

Chemical analyses* of the same samples gave a higher average lime requirement for the poor soils than for the good ones. It was also observed that the water-holding capacity was higher and the percolation rate lower in the case of poor soils.

These facts suggested a study of the rate of evaporation of water from soils of the two classes, and also of the effect of lime upon the rate of evaporation.

B. EVAPORATION EXPERIMENTS

For this study, two good and two poor soils were examined. Following the method used by Keen (8), the soil samples were moistened and supported on specially constructed trays in drying chambers where they were weighed periodically to determine the loss of water by evaporation. The apparatus was arranged as in Fig. 1 to enable the temperature of the samples to be kept constant during the experiment. A constant temperature bath *B*, filled with water, was maintained at 25° C. It contained six glass drying chambers *C*, 4½ in. in diameter and 5 in. deep, supported by a wooden lid that covered the bath. These contained 50 cc. of concentrated sulphuric acid and were covered by glass plates made air tight by a vaseline seal. In each drying chamber a soil sample *S* was placed, and the rate of evaporation was determined by weighing the samples at intervals on an analytical balance supported above the constant temperature bath. The latter was on a rotating stand so that any one of the six samples could be weighed without removing it from its drying chamber. During the weighing the aperture in the lid of the drying chamber was only about 5 or 6 sq. mm. in area. The samples were weighed every 15 min. until the weights became approximately constant, after which they were completely dried at 105° C. and the weight of dry soil

* *Chemical analyses were carried out by the Chemistry Department of Macdonald College.*

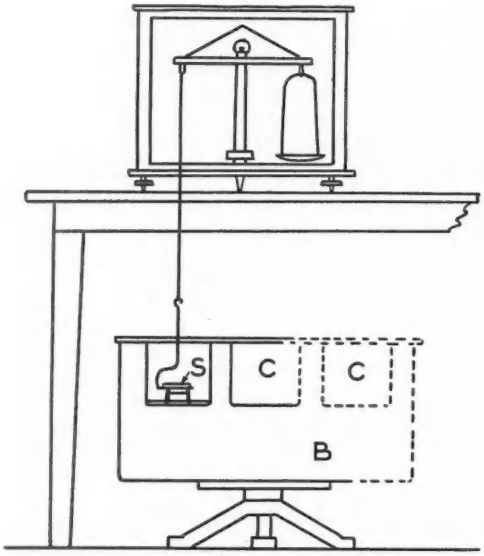

FIG. 1. *Apparatus for the determination of the rate of evaporation of water from the soil (after Keen).*

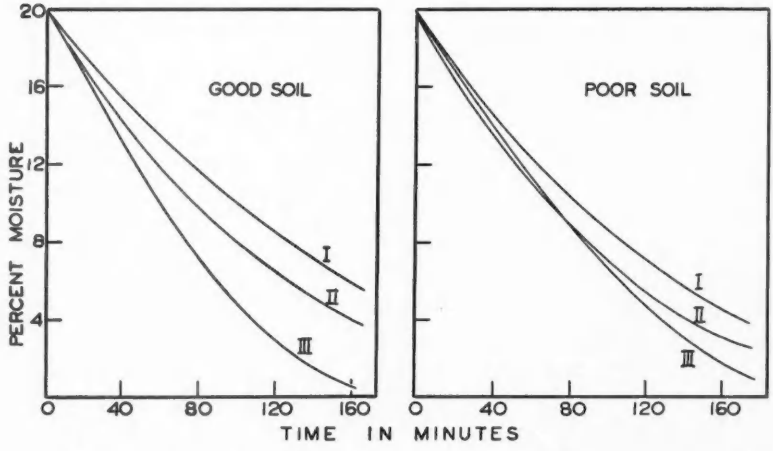

FIG. 2. *Rate of evaporation of water from soils. Curve I shows the rate of loss of moisture from the untreated soil; Curve II is obtained after treatment with limewater; Curve III is obtained after ignition at 700° C. for one hour.*

was determined. The percentage of moisture present at any time could then be calculated and the different soil samples compared.

It was not easy to secure consistent results from duplicate samples. Nevertheless, the general shape of the drying curves may be established. Typical results for one good and one poor soil are shown in Fig. 2.

To study the effect of liming, samples were moistened with limewater and observed as before. The effect of the organic portion of the soil was also studied by observing the rate of evaporation from samples which had been ignited at 700° C. for one hour. Typical results are included in Fig. 2.

The drying curves indicate no significant difference in the rate of evaporation from good and from poor soils. It is, however, clear that treatment with lime hastens the rate at which moisture is lost from the sample; removal of organic matter by ignition produces the same effect. Owing to the variability in the results from different samples it is impossible to say whether liming has a relatively greater effect upon the good or the poor soils; neither is it evident whether the improved crop response, which has been observed upon addition of lime to the poor soils, can be attributed to changes in physical condition.

C. Moisture Equivalent

The rate of evaporation from a soil depends, among other factors, upon the tenacity with which it holds water. To study this property, measurements of moisture equivalent (3) were made upon a number of samples. The moisture equivalent is the percentage of moisture, in terms of dry weight, which a soil can retain when subjected to a force equal to approximately 1,000 times gravity. A special centrifuge is used, fitted with suitable soil cups and adjusted to run at 2440 r.p.m. The method was as follows: a volume of 30 cc. of soil after passing through a 1 mm. sieve, was measured into each centrifuge soil cup. Filter paper was used to cover the perforated sides of the soil cups, and the weight of the filter paper was included with the weight of each empty cup. The samples were moistened from below by allowing the soil cups to stand in distilled water to a depth of 7 or 8 mm. for 15 min. After draining in a covered vessel for 20 to 24 hr., the samples were centrifuged in the machine at a speed of 2440 r.p.m. for 40 min. The samples were then weighed, dried in an electric oven at 105° C., and after cooling in a desiccator were again weighed. The ratio of the moisture retained after centrifuging to weight of dry soil gives the moisture equivalent.

Four good and four poor soils were examined. The average value of moisture equivalent was 26.4% for the former and 30.3% for the latter. Allowing for the deviations among the samples, the difference is not enough to be significant, although it indicates that the poor soils hold water more tenaciously. The samples whose drying curves are shown in Fig. 2 were found to have almost identical values for moisture equivalent: *viz.*, 30.9 and 30.6% for the good and poor samples respectively. Hence, there is no evident relation between moisture equivalent and rate of evaporation for the soils studied.

D. Heat of Wetting

It has been known for some time that a measurement of the heat of wetting (2) of a soil offers a means for estimating the proportion of material in the colloidal state. The heat of wetting is the heat, in calories, evolved when 1 gm. of dry soil is wetted with water. This quantity was determined for a number of samples by the method of Janert (7).

For each determination, from 10 to 20 gm. of soil was placed in a glass weighing tube, dried at 105° C. overnight, and the weight of dry soil determined. The stopper was sealed by applying a small quantity of melted paraffin wax, and the sealed weighing tube placed in a Dewar vessel containing enough water to make a total volume of 100 cc. when the soil was added. The Dewar vessel, fitted with a stirrer and a Beckmann thermometer, was closed and allowed to reach a uniform temperature. The weighing bottle was then removed from the water, and, with a minimum of handling, the stopper was removed, the soil poured into the water, and the temperature rise noted. Knowing the water equivalent of the calorimeter (which must be determined separately), the heat of wetting per gram of dry soil can be calculated. Typical results are given in Table III.

TABLE III

Heat of wetting of Quebec soils

"Good" soils		"Poor" soils	
Sample No.	Heat of wetting, cal. per gm.	Sample No.	Heat of wetting, cal. per gm.
1a	3.33	7a	3.66
2a	5.09	8a	3.14
3a	2.59	9a	3.07
5a	5.26	10a	3.47
13a	5.28	7b (subsoil)	1.84

By an analysis of variance or by the use of Fisher's t table (5) it is found that there is no significant difference between the heat of wetting of the good and poor samples. It is strongly indicated, however, from Tables I and III, that the heat of wetting is correlated with loss on ignition, but is only slightly dependent on the amount of clay in the sample. This point will be examined in Part II which will deal with virgin soils.

E. Volume Weight under Field Conditions

This experiment was an attempt to detect a change in the volume weight due to heavy lime treatment. The volume weight is defined as the weight of oven-dry soil per unit volume. If expressed in grams per cubic centimeter

it is evidently numerically equal to the apparent specific gravity. If measured in the field, upon undisturbed soil, it is a measure of the compactness.

Various methods have been described to determine the volume weight (6). In these tests, however, the samples were taken and the measurements made with a specially constructed instrument described below.

The soil sampler and its method of use are illustrated in Fig. 3. The sampler is made from steel tubing $3\frac{1}{4}$ in. in diameter, 4 in. long, and of wall thickness $\frac{1}{16}$ in. Two quadrants of the tube are used. These are sharpened, fitted with end plates and handles, and hinged together by means of a $\frac{1}{8}$ in. steel rod. In order to make a measurement, an area about one foot square must be levelled. The open sampler is placed so that it rests upon the levelled ground in the form of a semi-cylinder with convex side up (Fig. 3A). The steel rod which acts as hinge-pin projects about $2\frac{1}{2}$ in. on each side of the sampler. Upon these projections two flat boards 4 by 10 in. are placed. The operator stands upon these boards and, by rotating the handles of the instrument, forces the cutting edges into the ground (Fig. 3B). In this way a semi-cylindrical sample is obtained whose volume is accurately known. With the present instrument the semi-cylinder is 8.4 cm. in diameter, 10.0 cm. long, and has a volume of 277 cc. The sampler containing the soil is weighed upon a spring balance, (Fig. 3C), and samples are taken for moisture determinations, so that the volume weights may be expressed on oven-dry basis.

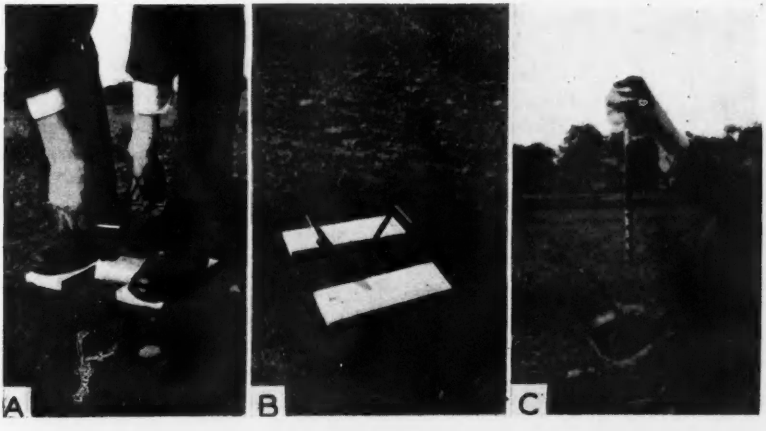

FIG. 3.

Measurements were made at two different locations on the farm of Mr. L. J. Scott, Sawyerville, in Compton Co., Que. At the first location, samples were taken from two neighboring plots, one of which had received, four years before, an application of pulverized limestone at the rate of six tons per acre, while the other had received none. The beneficial effect of lime upon the crop was still evident. Eleven samples were taken from each plot and suffi-

cient moisture determinations were made to reduce weights to oven-dry basis. The results are recorded in Table IV.

The difference in volume weights required for significance ($P = 0.05$) is 0.036 gm. per cc.; the difference found, *viz.*, 0.025 gm. per cc., is therefore not significant.

At the second location, on the same farm, similar tests were made on two other plots, one of which had received a recent heavy application of lime. The results again showed no significant difference.

TABLE IV

VOLUME WEIGHTS OF LIMED AND UNLIMED SOILS

Limed plot		Unlimed plot	
Volume weights, gm. per cc.		Volume weights, gm. per cc.	
0.761		0.744	
0.801		0.849	
0.718		0.795	
0.758		0.791	
0.761		0.791	
0.755		0.697	
0.712		0.752	
0.744		0.712	
0.754		0.765	
0.697		0.765	
0.683		0.755	
Mean	0.740	Mean	0.765

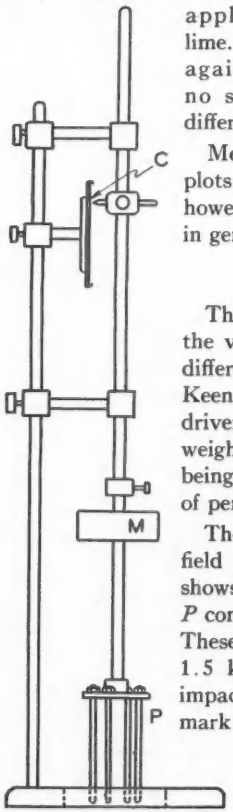

FIG. 4. *Apparatus for measuring the penetration resistance of the soil.*

Measurements were also made on limed and unlimed plots at Macdonald College with the same result. Here, however, a difference was not anticipated, as lime produces, in general, no marked change in the crop response.

F. PENETRATION EXPERIMENTS

These tests were carried out for the same purpose as the volume weight measurements, *viz.*, to detect possible differences in physical properties due to lime treatment. Keen (9) described experiments in which a metal rod was driven into the ground by repeated blows of a falling weight, the depth of penetration for each succeeding blow being measured and curves plotted to illustrate the rate of penetration.

The apparatus used here was designed to simplify the field readings and to give permanent records. Fig. 4 shows the form of construction. The penetrating portion P consisted of four $\frac{1}{4}$ in. brass rods with square-cut ends. These rods were driven into the ground by a mass M of 1.5 kg. falling through a fixed distance. After each impact the depth of penetration was recorded by a punch-mark on a 3 by 5 in. card C attached to the frame of the device. A number of traces could be made on the same card by sliding it sideways, after which the card was removed from the device and the depth of penetration per impact measured. The apparatus is not satisfactory in stony ground. In fact, pene-

tration measurements should not be attempted in such soils. A few stones, however, do not interfere with the use of the device because it is usually possible to detect the obstruction by the difference in the sound caused by the impact.

Penetration tests were carried out on two adjacent plots on the farm of Mr. L. J. Scott at Sawyerville. One of these had received a heavy treatment of lime several years before the test. Ten traces were obtained from each plot and these furnish the data for the curves shown in Fig. 5.

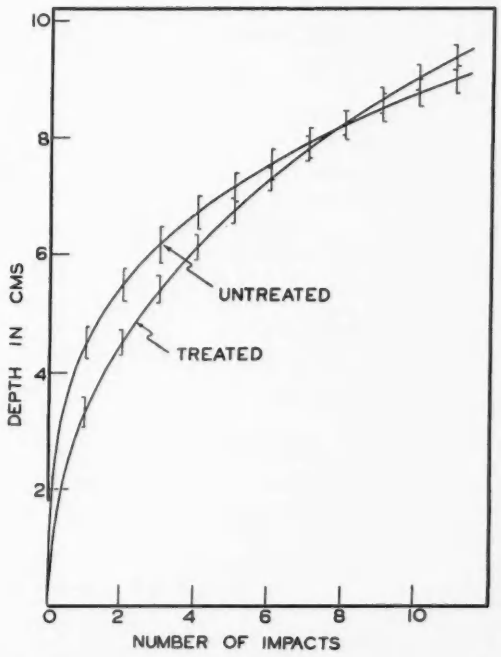

FIG. 5. *Rate of penetration. The vertical lines indicate the probable errors in the determination.*

The curves illustrating the rate of penetration can be represented fairly accurately by equations of the form $y = ax^b$, where y is the depth of penetration and x is the number of impacts. Although the tests were made within a few feet of the line separating the treated from the untreated plot, the possibility of a variation in the soil, other than that caused by the lime, must not be overlooked. Nevertheless, it is suggested that near the surface the treated plot offers significantly more resistance to penetration than the untreated one. This is caused, perhaps, by increased granulation due to the added lime.

G. Apparent Density, Pore Space, Etc., of Laboratory Samples

The apparent difference in the resistance to penetration, mentioned in the previous paragraph, suggested a comparison of several other physical properties. The method of the Keen-Raczkowski "box" experiment (10) enables measurements of apparent and real density, pore space, moisture content in saturated soil, and volume expansion upon wetting to be measured. For this determination, finely pulverized soil is packed into a shallow cylindrical box which has a number of holes bored through the bottom. After the dry soil is weighed it is allowed to reach saturation by taking up water, and as a result the soil swells, thrusting up a dome-shaped extrusion above the top of the box. This is removed with a sharp knife and is used to determine the "volume expansion", *i.e.*, the percentage increase in volume of the saturated soil over the apparent volume of the original soil. The amount of water taken up per unit volume of soil may also be determined as well as the other properties enumerated above. The details of the procedure are given by Coutts (4) or Wright (16) and will not be repeated here. The measurements were made with samples of air-dried soil taken from the same plots that had been used for resistance to penetration and for measurement of volume weight under field conditions as described above. The results of duplicate analyses are given in Table V.

TABLE V

Physical properties of soil by the "box" method

——	Apparent density, gm. per cc.	Real density, gm. per cc.	Pore space, %	Moisture content of sat'd soil, %	Volume exp'n upon wetting, %
Plot A_1 treated	1.04	2.62	56.3	61.5	9.3
	1.04	2.60	56.1	61.0	7.8
Plot A_2 untreated	1.04	2.62	56.7	62.8	10.0
	1.04	2.65	56.8	61.6	9.1
Plot B_1 treated	0.97	2.58	57.8	66.7	8.0
	0.97	2.56	57.7	66.6	9.1
Plot B_2 untreated	1.01	2.66	57.6	63.2	7.8
	0.99	2.61	57.6	64.8	8.4

Plot A_1 had received lime at the rate of six tons per acre four years before the samples were taken, and the crop still showed a marked improvement in growth over plot A_2 which had received no lime. Plots B_1 and B_2 were several hundred yards from A_1 and A_2. Plot B_1 had received a heavy application of lime two years before the samples were taken.

It is easily seen from the above figures that heavy lime applications have produced no detectable difference in the physical properties enumerated. This agrees with the absence of significant difference in volume weights under

field conditions. It does not, of course, preclude the possibility of differences in soil structure which must be assumed to account for the apparent difference in resistance to penetration previously mentioned.

Summary

In the surface layers, good alfalfa soils of Missisquoi and Brome Counties have a preponderance of fine gravel, coarse and medium sand; the poor soils have more very fine sand and silt.

In the deeper layers, good alfalfa soils have more fine gravel; the poor soils have more very fine sand and silt.

The effect of lime treatment on the rate of evaporation of water is approximately equal for good and for poor soils.

There is no significant difference in the moisture equivalent or the heat of wetting of good and poor soils, in the few samples studied.

There is evidence that heat of wetting depends to a greater extent on the amount of organic material in these soils than it does upon clay.

Lime treatment produces no significant difference in the volume weight under field conditions, volume weight of laboratory samples, pore space, moisture content of saturated soil, or volume expansion upon wetting, but does, apparently, increase the granulation near the surface as tested by penetration experiments.

Apparatus is described for the measurement of volume weight of soil *in situ* and for the measurement of resistance to penetration.

Acknowledgment

The author is indebted to the Department of Agronomy, Macdonald College, for a classification of the alfalfa fields.

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PHYSICAL PROPERTIES OF MINERAL SOILS OF QUEBEC

PART II. VIRGIN SOILS[1]

By W. Rowles[2]

Abstract

Fifty-three samples from various horizons of virgin soil from different parts of the province have been analyzed for the following properties: organic carbon, loss on ignition, clay, silt, sand, moisture at the sticky point, moisture take up at 50% relative humidity, pore space, heat of wetting, volume expansion, maximum moisture taken up, index of texture, apparent and absolute specific gravity. Correlation coefficients and regression equations have been derived to trace the relations existing between these properties, and it is shown that the organic content of the soil is the most important factor in determining the physical behavior. A comparison of the pipette and hydrometer methods of mechanical analysis is described.

Introduction

Part I of this paper dealt with cultivated soils located, for the most part, in the counties of Missisquoi and Brome, Que. The studies now to be described were of samples from a wider area of Quebec and were carried out to obtain information on soils of which the natural horizons had never been disturbed by cultivation*. At the same time, a comparison of the pipette and hydrometer methods of mechanical analysis was made to test the suitability of the latter method for use in a proposed soil survey.

One of the objects of this study was to obtain data on the texture of the different horizons of various soil types. In addition to the important quality of texture, there are a number of other soil "constants" which are useful, *viz.*, moisture content at the point of stickiness, moisture taken up at 50% relative humidity, maximum water-holding capacity, loss on ignition, volume expansion upon wetting, heat of wetting, pore space, and the apparent and true specific gravities. Some of these constants are known to be related. Numerous attempts have been made to discover a "single-valued constant" that might serve to describe adequately a given soil, and although, as Keen points out, the realization of this hope seems unlikely, the search has furnished much information of value.

In the present work all the above-mentioned constants have been measured, together with some others, and a number of relations have been traced between them. Several types of Quebec mineral soils were studied, namely, those classified as podsol (lowland and upland), brown earth, sandy clay, heavy clay and orchard soil (15). The various horizons were examined separately.

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* *A very brief preliminary report of part of this work has already been published (19).*

Methods of Analysis

A. Mechanical Analysis

(a) Pipette Method

Of the many methods available to determine the texture of a soil, that described by Robinson (18) has been adopted by the International Society of Soil Science. It is based on the assumption that soil particles fall through a viscous medium with a velocity (V) given by the well-known law of Stokes:

$$V = \frac{2g(\sigma - \rho)r^2}{9\eta}$$

where g is the acceleration due to gravity, σ and ρ are the densities of the particle and medium respectively, r is the radius of the equivalent spherical particle, and η is the coefficient of viscosity of the medium.

In practice, the soil sample is thoroughly dispersed in water and the suspension is allowed to stand undisturbed while the particles settle. At definite times and depths, small samples are removed from the suspension by means of a pipette and the amount of solid material in each is determined. From Stokes' Law, the weight of solid material may be expressed as the percentage of silt, clay, etc., in the original sample. The percentage of larger particles, *e.g.*, sand, is more conveniently determined by sieving.

Robinson's method, modified in 1933 (10), was used to determine the percentages of the following International fractions: coarse sand, 2.0–0.2 mm. diameter; fine sand 0.2–0.02 mm.; silt 0.02–0.002 mm.; clay <0.002 mm. In addition to these separates, a determination of clay <0.005 mm. was made by pipetting at the appropriate time and depth. Dispersion was effected by the use of sodium hydroxide. The results are given in Table I.

(b) Hydrometer Method

The method of mechanical analysis described above demands considerable time. To shorten the procedure, Bouyoucos (1, 2) has suggested the use of a special hydrometer which may be placed in the soil suspension, the readings giving a measure of the percentage of silt and clay in the sample. For the preliminary dispersion he recommends an electrically-driven drink mixer with a special paddle. The method has been criticized because of its empirical nature and the variable results which are obtained with some soils due to the disintegration of the particles during vigorous stirring. It was considered desirable to test the applicability of this quick method to Quebec soils.

The procedure here followed was that recommended by Bouyoucos (3), except that additional hydrometer readings were taken at times estimated to give results on the International scale, as well as those required by the American scheme of classification. A partial list of the observed results is included in Table I.

TABLE I

MECHANICAL ANALYSIS OF QUEBEC MINERAL SOILS

Sample number	Name and type o soil	Horizon	International pipette method							Hydrometer method					
			Coarse sand 2.0–0.2 mm.	Fine sand 0.2–0.02 mm.	Silt .02–.002 mm.	Clay .005 mm.	Fineclay .002 mm.	Loss on ignition	$CaCO_3$	Coarse sand (40 sec.)	Total sand (1 min.)	Silt 100 − (total sand + 005 clay)	Clay .005 mm. (1 hr.)	Clay .002 mm. (2 hr.)	Silt and clay (5 min.)
	BROWN EARTH														
1	Cowansville	B	39.1	25.4	20.8	17.4	11.1	6.84	0	54.5	58.5	26.7	14.8	8.9	35.3
2	Shefford	B	59.5	13.5	12.0	12.3	9.9	6.60	0	62.7	64.8	25.5	9.7	5.2	26.8
3	Summerlea	A	19.4	32.5	16.6	19.2	14.8	14.70	0	39.9	47.3	39.7	13.0	11.1	32.8
4	Summerlea	B	26.5	36.0	15.7	19.7	14.1	8.14	0	46.6	50.8	36.7	12.5	9.8	31.0
5	Summerlea	C	26.3	39.7	16.3	18.5	13.7	5.07	0	46.9	51.0	34.5	14.5	12.1	32.4
6	Eastman	A	28.6	25.1	18.0	17.2	12.6	14.44	0	35.8	37.8	28.0	34.2	29.8	43.6
7	Eastman	B	41.7	29.1	12.6	12.9	9.3	7.26	0	57.8	59.9	28.9	11.2	6.6	28.6
8	Eastman	C	26.5	40.9	20.2	17.8	11.7	1.78	0	53.2	56.3	27.9	15.8	12.4	32.7
9	Morgan's Wood (Senneville)	A	16.1	27.8	18.1	29.5	21.4	19.53	0.56	39.2	41.5	46.3	12.2	10.6	43.1
10	Morgan's Wood (Senneville)	B	14.3	41.4	26.4	27.4	16.6	5.30	1.84	31.3	33.1	40.3	26.6	19.7	45.0
11	Morgan's Wood (Senneville)	C	8.6	52.0	27.7	17.0	9.1	4.36	2.24	27.9	32.2	52.7	15.1	10.8	41.9
	UPLAND PODSOL														
12	Stukeley	A_2	30.6	38.9	21.5	12.9	7.7	2.91	0	54.2	56.7	32.5	10.8	8.4	28.2
13	Stukeley	B_1	37.8	27.8	15.0	11.8	8.5	13.57	0	50.9	56.3	36.3	7.4	5.2	20.8
14	Stukeley	B_2	37.9	33.9	15.3	11.5	7.8	6.27	0	56.0	58.7	31.7	9.6	7.5	28.7
15	Stukeley	C	37.2	39.1	14.6	14.6	10.3	2.55	0	58.5	62.2	27.2	10.6	7.1	27.2
16	Ste. Adele	A_1	2.6	44.8	16.0	17.7	11.1	30.88	0.82	48.7	54.2	35.9	9.9	7.9	20.4
17	Ste. Adele	A_2	3.1	77.6	14.1	12.8	9.1	1.92	0	50.8	55.9	37.3	6.8	6.4	16.0
18	Ste. Adele	B_1	2.5	62.3	11.4	11.9	9.9	19.25	0	51.3	61.8	31.0	7.2	6.3	10.3
19	Ste. Adele	B_2	3.6	65.3	13.1	11.3	8.5	7.78	0	56.3	63.9	30.2	5.9	5.0	11.3
20	Ste. Adele	C	20.6	57.8	9.5	8.3	5.3	3.13	0	66.2	70.3	24.3	5.4	4.9	11.5

	SANDY CLAY														
21	Marieville	B_1	24.0	29.4	18.4	31.2	23.9	3.17	0	45.5	50.7	19.6	29.7	21.7	40.0
22	Marieville	B_2	34.8	38.3	13.2	12.9	9.7	1.55	1.48	65.0	69.0	22.1	8.9	6.7	18.9
23	Marieville	C	54.3	14.4	15.9	16.3	10.6	1.33	2.83	61.4	67.5	23.1	9.4	7.4	24.5
24	Pike River	A	1.6	47.1	21.8	29.9	24.5	11.20	0	35.5	40.7	43.1	16.2	14.1	37.4
25	Pike River	B_2	3.2	52.2	17.4	30.8	27.3	2.86	0	36.8	42.8	26.2	31.0	28.9	39.8
26	Pike River	C	4.8	15.6	27.4	64.8	50.0	3.27	0	14.4	16.5	19.3	64.2	55.6	78.5
27	Laprairie	A	11.3	15.4	22.2	45.2	36.0	16.43	0	16.4	18.6	72.9	8.5	6.4	60.7
28	Laprairie	B	29.3	27.3	16.1	26.6	21.2	3.87	0.25	44.4	46.5	24.3	29.2	25.2	40.4
29	Laprairie	C	3.9	59.3	28.3	11.1	6.7	1.34	0.25	29.9	35.9	52.2	11.9	7.3	36.1
30	St. Cuthbert	A	17.6	41.8	17.6	22.0	16.1	8.56	0.43	35.5	38.1	45.1	16.8	13.8	37.6
31	St. Cuthbert	B	23.2	35.0	19.0	25.9	18.6	4.65	0.40	27.2	29.8	33.5	36.7	31.6	53.1
32	St. Cuthbert	C	30.8	16.2	25.0	36.8	25.8	3.94	0.47	10.0	12.3	29.6	58.1	51.4	78.1
33	Three Rivers	A	3.0	26.8	38.1	36.5	22.7	10.52	0.80	21.3	23.9	41.5	34.6	24.0	58.7
34	Three Rivers	B	1.5	25.1	39.6	41.6	25.8	7.95	0.70	17.7	20.4	41.7	37.9	27.2	65.7
35	Three Rivers	C	0.6	25.3	44.9	43.1	27.1	2.89	0.40	10.8	12.8	44.9	42.3	33.8	69.2
	HEAVY CLAY														
36	St. Lin	A	7.3	36.2	18.6	35.8	30.1	8.44	0.24	24.5	29.4	38.2	32.4	29.5	50.3
37	St. Lin	B	11.6	15.5	17.4	58.3	51.7	4.72	0.37	9.2	10.4	21.1	68.5	63.8	81.8
38	St. Lin	C	6.8	8.0	18.4	73.0	63.3	3.26	0.66	6.9	8.2	15.4	76.4	70.9	87.3
39	Laprairie	A	3.8	5.1	20.0	71.5	58.5	15.98	0	15.4	17.5	24.8	57.7	51.6	74.8
40	Laprairie	B	1.9	2.5	24.6	85.9	64.4	5.30	0.25	7.8	8.7	9.2	82.1	76.3	91.3
41	Laprairie	C	5.1	9.5	30.6	63.5	47.5	4.00	1.22	14.3	16.6	19.1	64.3	55.6	78.2
42	Macdonald College	A	0	0	17.1	85.8	78.9	4.99	0.68	2.8	2.8	14.3	82.9	76.1	92.6
43	Macdonald College	B_1	0	0	19.3	85.9	78.7	4.18	0	5.7	5.7	11.4	82.9	76.1	92.8
44	Macdonald College	B_2	0	0	17.6	84.0	75.8	4.34	1.61	6.7	6.7	14.5	78.8	73.1	91.8
45	Macdonald College	C	0	0	20.9	80.3	68.6	5.56	3.96	7.7	7.7	15.6	76.7	70.0	91.3
46	Low	A	0.4	40.8	38.3	23.4	16.4	1.42	0.24	11.4	15.3	68.4	17.3	15.4	52.4
47	Low	B	2.7	15.8	33.1	58.1	44.0	1.78	0.35	9.0	11.3	35.3	53.4	48.4	75.3
48	Low	C	1.3	4.9	34.1	73.8	46.0	1.67	0.45	3.6	5.5	26.2	68.3	62.2	90.1
	ORCHARD SOIL														
49	St. Hilaire	A	28.6	19.3	16.1	21.9	17.7	12.84	0	48.9	52.1	26.2	21.7	21.7	41.2
50	St. Hilaire	B	54.0	18.4	12.7	14.7	11.3	6.43	0	58.9	61.5	29.9	8.6	11.1	26.8
51	Frelighsburg	A	21.4	36.1	22.9	18.7	10.6	9.28	0	45.2	48.0	42.9	9.1	11.5	35.9
52	Frelighsburg	B	30.0	39.3	19.6	12.7	6.6	3.70	0	51.7	56.9	37.4	5.7	9.7	28.9
53	Frelighsburg	C	32.8	42.0	19.7	11.1	5.2	1.74	0	58.2	61.2	33.1	5.7	8.6	26.7

TABLE II

PHYSICAL ANALYSES OF TYPICAL MINERAL SOILS OF QUEBEC

(Sample numbers correspond with Table I)

Symbol	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
Sample No.	Organic carbon, %	Loss on ignition, %*	Clay .002 mm., %	Silt .02–.002 mm., %	Moisture at sticky point, %	Moisture at 50% relative humidity, %	Pore space, %	Heat of wetting, cal./gm.	Volume expansion, %	Max. moisture taken up*	Loss on ignition, inorganic (B − 1.724A)	Index of texture	Moisture in air-dry soil	Apparent specific gravity	Absolute specific gravity
BROWN EARTH															
1	2.51	6.84	11.1	20.8	33.2	1.62	54.0	3.31	8.4	53.8	2.51	23.2	3.05	1.12	2.29
2	2.19	6.60	9.9	12.0	31.0	2.61	49.2	3.08	14.8	43.8	2.82	16.4	2.74	1.32	2.27
3	9.05	14.70	14.8	16.6	76.2	4.85	63.8	7.38	25.0	122.8	0.00	65.8	4.81	0.71	1.67
4	3.09	8.14	14.1	15.7	40.1	3.77	54.3	4.30	16.2	60.4	2.81	27.6	4.16	1.12	2.13
5	1.49	5.07	13.7	16.3	28.2	2.76	52.7	2.88	9.5	52.5	2.51	15.0	3.68	1.13	2.23
6	7.45	14.44	12.6	18.0	56.0	3.68	61.4	5.19	13.0	82.6	1.58	45.3	3.57	0.87	2.03
7	3.13	7.26	9.3	12.6	34.8	3.34	56.2	4.08	10.6	61.2	1.86	20.6	2.61	1.04	2.16
8	0.17	1.78	11.7	20.2	14.6	0.62	41.8	0.64	4.8	26.4	1.49	1.1	0.46	1.52	2.54
9	10.37	19.53	21.4	18.1	74.9	4.21	65.1	10.90	30.6	119.2	1.68	66.1	13.22	0.82	1.69
10	2.84	5.30	16.6	26.4	40.8	3.65	60.1	9.41	17.1	72.9	0.40	29.7	7.26	1.02	2.12
11	0.44	4.36	9.1	27.7	43.5	4.55	63.1	12.61	15.0	73.4	3.60	31.4	7.98	1.05	2.38
UPLAND PODSOL															
12	1.16	2.91	7.7	21.5	39.8	0.96	46.3	1.74	5.5	40.7	0.91	25.9	1.25	1.23	2.22
13	5.94	13.57	8.5	15.0	51.7	4.36	61.7	7.10	8.8	75.8	3.33	38.6	8.85	0.93	2.17
14	2.06	6.27	7.8	15.3	32.9	2.31	53.3	3.35	11.7	51.2	2.73	18.5	4.31	1.19	2.25
15	0.66	2.55	10.3	14.6	23.3	1.02	43.0	1.87	9.9	35.3	1.41	8.0	1.56	1.41	2.39
16	20.11	30.88	11.1	16.0	158.6	8.44	66.8	11.10	24.2	221.0	0.00	149.1	9.90	0.42	1.05
17	1.00	1.92	9.1	14.1	34.5	0.60	52.2	0.76	7.0	47.5	0.20	18.4	0.57	1.18	2.37
18	6.30	19.25	9.9	11.4	77.0	8.13	63.5	6.79	11.4	99.4	8.37	66.0	8.83	0.73	1.93
19	2.96	7.78	8.5	13.1	52.5	5.16	60.7	4.23	11.8	71.8	2.68	38.7	5.39	1.05	2.24
20	1.09	3.13	5.3	9.5	30.2	2.63	33.8	2.22	12.0	31.4	1.25	14.5	2.45	1.26	1.75
SANDY CLAY															

Sandy Clay															
21	0.37	3.17	23.9	18.4	23.2	1.59	47.9	4.04	7.5	39.0	2.53	12.5	3.06	1.34	2.39
22	0.14	1.55	9.7	13.2	14.0	0.32	35.7	1.54	5.5	23.2	1.31	0.0	0.58	1.64	2.46
23	0.08	1.33	10.6	15.9	14.0	0.37	36.9	0.64	3.9	24.0	1.19	0.3	0.47	1.56	2.43
24	5.59	11.20	24.5	21.8	53.6	2.99	60.7	4.62	17.9	80.1	1.52	43.9	3.88	0.92	2.00
25	0.17	2.86	27.3	17.4	25.4	1.58	49.4	2.58	13.7	47.1	2.57	14.3	3.04	1.26	2.25
26	0.06	3.27	50.0	27.4	32.7	2.97	57.1	4.63	14.7	56.5	3.17	28.6	4.45	1.19	2.49
27	6.81	16.43	36.0	22.2	67.2	5.93	64.7	6.34	14.2	106.6	4.71	61.9	6.78	0.74	1.79
28	0.65	3.87	21.2	16.1	25.9	2.39	50.4	2.90	12.3	45.0	2.75	14.4	4.19	1.30	2.29
29	0.22	1.34	6.7	28.3	21.0	0.04	44.4	1.37	4.3	30.6	0.96	8.4	0.26	1.49	2.64
30	3.70	8.56	16.1	17.6	48.4	3.20	54.9	4.26	12.9	61.5	2.18	36.5	3.73	1.02	1.98
31	1.16	4.65	18.6	19.0	37.4	3.36	54.4	2.38	12.0	56.9	2.65	25.8	3.63	1.12	2.22
32	0.00	3.94	25.8	25.0	37.9	3.60	53.2	4.04	7.0	55.2	3.94	28.5	4.55	1.10	2.20
33	4.93	10.52	22.7	38.1	54.3	3.71	57.5	5.00	14.4	70.8	2.00	48.3	3.62	0.97	2.06
34	3.24	7.95	25.8	39.6	51.8	3.23	53.5	4.14	10.4	62.7	2.35	46.5	3.12	1.00	2.18
35	0.37	2.89	27.1	44.9	30.0	2.00	52.2	2.47	6.4	44.1	2.25	24.8	1.87	1.20	2.36
Heavy Clay															
36	2.47	8.44	30.1	18.6	43.0	4.17	56.0	4.08	13.4	59.2	4.18	34.3	4.57	1.13	2.24
37	1.12	4.72	51.7	17.4	46.2	4.93	59.5	5.11	11.1	67.3	2.79	40.8	5.44	1.07	2.34
38	0.80	3.26	63.3	18.4	48.4	4.96	61.0	5.71	17.7	64.8	1.88	45.4	5.20	1.17	2.54
39	7.49	15.98	58.5	20.0	57.3	4.80	62.4	6.56	13.5	80.2	3.07	55.5	8.20	0.94	2.11
40	3.27	5.30	64.4	24.6	40.0	3.71	54.6	5.04	13.8	57.9	0.00	39.1	6.35	1.16	2.19
41	1.02	4.00	47.5	30.6	31.3	2.48	53.9	3.46	10.3	51.9	2.24	28.4	3.70	1.21	2.31
42	3.00	4.99	78.9	17.1	39.8	3.73	53.1	5.79	19.6	56.9	0.00	39.8	5.49	1.19	2.11
43	2.07	4.18	78.7	19.3	33.9	3.60	56.2	6.78	23.1	61.2	0.61	33.9	5.46	1.19	2.20
44	1.43	4.34	75.8	17.6	40.2	3.29	57.9	5.04	20.9	55.2	1.88	40.2	4.70	1.20	2.26
45	0.57	5.56	68.6	20.9	38.2	2.75	56.9	4.78	19.6	62.2	4.57	38.2	4.00	1.13	2.21
46	0.31	1.42	16.4	38.3	24.5	0.95	46.5	1.34	8.2	35.6	0.89	16.3	0.75	1.36	2.37
47	0.07	1.78	44.0	33.1	33.4	2.62	53.0	2.88	16.0	51.1	1.66	29.7	1.90	1.20	2.56
48	0.00	1.67	46.0	34.1	37.3	2.96	55.8	3.25	18.5	62.5	1.67	36.1	2.46	1.16	2.34
Orchard Soil															
49	6.10	12.84	17.7	16.1	56.8	3.53	57.5	5.61	23.9	65.2	2.32	47.2	4.50	0.97	1.88
50	2.22	6.43	11.3	12.7	33.3	2.14	52.8	2.91	17.5	52.8	2.60	18.8	2.46	1.14	2.14
51	3.89	9.28	10.6	22.9	47.8	2.10	60.4	3.66	7.4	76.8	2.56	36.3	3.07	0.86	2.06
52	1.56	3.70	6.6	19.6	28.9	1.23	49.9	1.55	8.0	42.4	1.01	15.0	1.65	1.28	2.38
53	0.27	1.74	5.2	19.7	19.4	0.43	40.8	0.60	2.2	25.9	1.27	4.4	0.38	1.54	2.53

* *Figures for some Quebec podsol soils have been given by Gray and McMaster (6) and Gray and Taylor (7).*

B. Moisture at the Sticky Point

This measurement, originally advocated by Hardy (8), was determined by adding sufficient water to the dry soil so that, upon thorough kneading, the soil was not quite sticky, but could be rolled out into a cylinder about 2 mm. in diameter without breaking up. After some practice the point can be judged quite accurately. The moist soil was weighed, dried at 105° C. overnight, and weighed again. The "sticky point" is expressed as the percentage of water in the moist soil, on the basis of oven-dry soil weight. As it cannot be determined for sandy soils, Olmstead (16) has suggested the use of minimum water of saturation. This "constant" has been measured for a number of Quebec soils but will not be included here. The results for the percentage of moisture at the sticky point are given in Table II; from these values and the percentage of sand it is possible to calculate the index of texture as proposed by Hardy (9), who defined index of texture as the percentage of moisture at the sticky point minus one-fifth of the percentage of sand. This is also included in the table.

C. Heat of Wetting

The heat of wetting is defined as the heat in calories evolved when one gram of dry soil is wetted with water. It was measured by the method of Janert (11), briefly outlined in Part I.

D. Moisture Taken Up at 50% Relative Humidity

The hygroscopic coefficient formerly in use expressed the amount of water that a soil would take up from a saturated atmosphere. This has gradually been replaced by a determination of the amount of moisture taken up from an atmosphere kept at 50% relative humidity. The measurement has been proposed (5) as a means of estimating the amount of colloidal material in soil.

To make the measurement, samples were placed in weighing dishes in a vacuum desiccator, over sulphuric acid diluted to specific gravity of 1.329 at 25° C. The air pressure in the desiccator was reduced to a few centimeters of mercury and the system allowed to stand at reasonably constant temperature to reach equilibrium. The final constant weight of each sample was observed, after which it was dried at 105° C. overnight, and again weighed. The result is expressed as the percentage of moisture taken up by oven-dry soil.

E. Apparent and Real Specific Gravity, Maximum Moisture-holding Capacity, Pore Space, and Volume Expansion upon Wetting

All the above-mentioned properties may be measured in a single routine, usually known as the Keen-Raczkowski "box" experiment (14), outlined in Part I. The results of the determination on Quebec soils are presented in Table II.

F. Organic Carbon and Loss on Ignition

Loss on ignition was determined in the usual way by ignition at 700° C. for one hour; organic carbon was determined by the dry combustion method described by Read (17).

Experimental Results

In this section, three tables are given to include the more useful data from the numerous analyses that have been made. Tables I and II are self-explanatory; Table III is arranged for easy comparison of the two methods of mechanical analysis. The analyses were all carried out in duplicate, mean values being recorded in the tables. Through unforeseen circumstances it was impossible to make determinations of all the physical properties of every horizon of each soil studied. For convenience in the mathematical work it was desirable to use only those samples for which complete data were available. For this reason, much useful data which were obtained in the analyses have been omitted from the tables, and only those samples which were used in the calculations have been included.

TABLE III

Comparison of mechanical analyses by international pipette method and hydrometer method

No.	Soil type and location	Horizon	Clay (.005 mm.)		Clay (.002 mm.)		Silt and fine clay	
			Pipette method:	Hydrometer method: (1 hr.)	Pipette method:	Hydrometer method: (2 hr.)	Pipette method:	Hydrometer method: (5 min.)
	Brown Earth							
1	Cowansville	B	17.4	14.8	11.1	8.9	31.9	35.3
2	Shefford	B	12.3	9.7	9.9	5.2	21.9	26.8
3	Summerlea	A	19.2	13.0	14.8	11.1	31.4	32.8
4	Summerlea	B	19.7	12.5	14.1	9.8	29.8	31.0
5	Summerlea	C	18.5	14.5	13.7	12.1	30.0	32.4
6	Eastman	A	17.2	34.2	12.6	29.8	30.6	43.6
7	Eastman	B	12.9	11.2	9.3	6.6	21.9	28.6
8	Eastman	C	17.8	15.8	11.7	12.4	31.9	33.7
9	Senneville	A	29.5	12.2	21.4	10.6	39.5	43.1
10	Senneville	B	27.4	26.6	16.6	19.7	43.0	45.0
11	Senneville	C	17.0	15.1	9.1	10.8	36.8	41.9
	Upland Podsol							
12	Stukeley	A_3	12.9	10.8	7.7	8.4	29.2	28.2
13	Stukeley	B_1	11.8	7.4	8.5	5.2	23.5	20.8
14	Stukeley	B_2	11.5	9.6	7.8	7.5	23.1	28.7
15	Stukeley	C	14.6	10.6	10.3	7.1	24.9	27.2
16	Ste. Adele	A_1	17.7	9.9	11.1	7.9	27.1	20.4
17	Ste. Adele	A_2	12.8	6.8	9.1	6.4	23.2	16.0
18	Ste. Adele	B_1	11.9	7.2	9.9	6.3	21.3	10.3
19	Ste. Adele	B_2	11.3	5.9	8.5	5.0	73.8	11.3
20	Ste. Adele	C	8.3	5.4	5.3	4.9	63.1	11.5

TABLE III—*Concluded*

COMPARISON OF MECHANICAL ANALYSES BY INTERNATIONAL PIPETTE METHOD AND HYDROMETER METHOD—*Concluded*

No.	Soil type and location	Horizon	Clay (.005 mm.)		Clay (.002 mm.)		Silt and fine clay	
			Pipette method:	Hydrometer method: (1 hr.)	Pipette method:	Hydrometer method: (2 hr.)	Pipette method:	Hydrometer method: (5 min.)
	SANDY CLAY							
21	Marieville	B_1	31.2	29.7	23.9	21.7	42.3	40.0
22	Marieville	B_2	12.9	8.9	9.7	6.7	22.9	18.9
23	Marieville	C	16.3	9.4	10.6	7.4	26.5	24.5
24	Pike River	A	29.9	16.2	24.5	14.1	46.3	37.4
25	Pike River	B_2	30.8	31.0	27.3	28.9	44.7	39.8
26	Pike River	C	64.8	64.2	50.0	55.6	77.4	78.5
27	Laprairie	A	45.2	8.5	36.0	6.4	58.2	60.7
28	Laprairie	B	26.6	29.2	21.2	25.2	37.3	40.4
29	Laprairie	C	11.1	11.9	6.7	7.3	35.0	36.1
30	St. Cuthbert	A	22.0	16.8	16.1	13.8	33.7	37.6
31	St. Cuthbert	B	25.9	36.7	18.6	31.6	37.6	53.1
32	St. Cuthbert	C	36.8	58.1	25.8	51.4	50.8	78.1
33	Three Rivers	A	36.5	34.6	22.7	24.0	60.8	58.7
34	Three Rivers	B	41.6	37.9	25.8	27.2	65.4	65.7
35	Three Rivers	C	43.1	42.3	27.1	33.8	72.0	69.2
	HEAVY CLAY							
36	St. Lin	A	35.8	32.4	30.1	29.5	48.7	50.3
37	St. Lin	B	58.3	68.5	51.7	63.8	69.1	81.8
38	St. Lin	C	73.0	76.4	63.3	70.9	81.7	87.3
39	Laprairie	A	71.5	57.7	58.5	51.6	78.5	74.8
40	Laprairie	B	85.9	82.1	64.4	76.3	89.0	91.3
41	Laprairie	C	63.5	64.3	47.5	55.6	78.1	78.2
42	Macdonald College	A	85.8	82.9	78.9	76.1	96.0	92.6
43	Macdonald College	B_1	85.9	82.9	78.7	76.1	93.0	92.8
44	Macdonald College	B_2	84.0	78.8	75.8	73.1	93.4	91.8
45	Macdonald College	C	80.3	76.7	68.6	70.0	89.5	91.3
46	Low	A	23.4	17.3	16.4	15.4	54.7	52.4
47	Low	B	58.1	53.4	44.0	48.4	77.1	75.3
48	Low	C	73.8	68.3	46.0	62.2	90.1	90.1
	ORCHARD SOIL							
49	St. Hilaire	A	21.9	21.7	17.7	21.7	33.8	41.2
50	St. Hilaire	B	14.7	8.6	11.3	11.1	24.0	26.8
51	Frelighsburg	A	18.7	9.1	10.6	11.5	33.5	35.9
52	Frelighsburg	B	12.7	5.7	6.6	9.7	26.2	28.9
53	Frelighsburg	C	11.1	5.7	5.2	8.6	24.9	26.7

Discussion

COMPARISON OF PIPETTE AND HYDROMETER METHODS OF MECHANICAL ANALYSIS

From an examination of the data in Table III it may be seen that there is considerable variation between the results of the two methods of analysis. This is more evident for the smaller particle sizes of the 0.005 mm. and 0.002 mm. clays; it is less serious in the case of the larger separates which contain

silt. It is not easy to state unequivocally whether the hydrometer may safely be used to replace the pipette method, because the fair agreement which is generally obtained is seriously marred in some cases by very large discrepancies. For example, in the *A* horizon of Laprairie sandy clay (Sample No. 27), the values obtained for the 0.005 mm. clay are 45.2 and 8.5% respectively. It is unlikely that this is an error in observation as a similar difference was obtained in the analysis of 0.002 mm. clay for this sample, *viz.*, 36.0 and 6.4% respectively. The difference is evidently attributable to the difference in the two methods of analysis.

The advisability of examining the results statistically has been considered, but in view of the fact that there are occasional wide variations and because of the difficulty which these would introduce into the interpretation, it seemed best not to attempt such an analysis.

In seeking to describe soil samples accurately, the value of a method may well be inversely proportional to the chance of making a large error in the analysis. With this limitation, it is of no avail that most of the analyses be highly accurate if the remainder be very inaccurate. It is open to question whether this is true in the study of soil properties. Suffice it to say that on the basis of results obtained with Quebec soils, the hydrometer method usually gives reasonably accurate results, but, without doubt, very large errors may sometimes occur.

Relations Between Soil Constants

It is well known that some of the soil properties enumerated above are dependent on one another. Keen and Coutts (13) and Keen (12) have studied the relations between the sticky point, the loss on ignition, the moisture content in equilibrium with an atmosphere of 50% relative humidity, and the percentage clay content of the soil. From their work it appears that "the sticky point is largely controlled by the material in the soil that is driven off by ignition, while the soil moisture content at 50% relative humidity is controlled largely by the clay content."

Upon analyzing the results for Quebec soils, interesting facts appear, not all of which are in agreement with the results obtained for the soils examined by Keen and Coutts.

Scatter diagrams (not shown) of certain pairs of variables for the 53 samples already described indicate strong association in most cases, but little or none where clay is concerned. A calculation of the same simple and partial correlations that were given by Keen and Coutts for their original 39 samples, and later for the 250 soils from various parts of the world, shows that in some respects the Quebec samples depart significantly from the general behavior. Using, for the moment, Keen's notation in which C is the clay content, R is the moisture content in equilibrium with an atmosphere of 50% relative

humidity, I the loss on ignition, and S the moisture at the sticky point, the values of correlation coefficients, with their standard errors, are as follows:

TABLE IV

CORRELATION COEFFICIENTS (SIMPLE)

	Data for original 39 soils (Keen and Coutts)			Data for 250 soils (Keen)			Data for 53 Quebec soils		
	I	R	S	I	R	S	I	R	S
C	.364	.719	.317	.283 ± .060	.483 ± .050	.430 ± .053	−.108 ± .138	.231 + .133	.004 ± .140
I	—	.388	.865	—	.632 ± .039	.820 ± .021	—	.772 ± .057	.913 ± .024
R	—	—	.303	—	—	.670 ± .036	—	—	.830 ± .044

It may be observed that for Quebec soils none of the coefficients involving clay is significant, while all the others are highly significant and definitely larger than those previously reported.

A further comparison is possible by the use of partial correlation coefficients which are given in the following table, together with Keen's data.

TABLE V

PARTIAL CORRELATION COEFFICIENTS

—	Data for 39 soils (Keen and Coutts)	Data for 250 soils (Keen)	Data for 53 Quebec soils
SI.C	0.843	0.808 ± 0.023	0.919*
RC.I	.673	.410 ± .054	.340*
RI.C	.194	.590 ± .042	.824*
SC.I	.155	.362 ± .054	.252
RI.S	.095	.193 ± .063	.062
SC.R	.015	.163 ± .063	−.346*

*For the Quebec soils, values marked * are significant.*

The first and third of the significant values are higher than have previously been found, while the last exhibits most unexpected behavior in that it is negative. This is so different from the result found by Keen that it seemed wise to examine the data in greater detail, taking more variables into consideration. These extended calculations were made by the method of Wallace and Snedecor (20). When each variable is considered with respect to each of the others, 59 simple correlation coefficients are obtained, as shown in Table VI.

TABLE VI

CORRELATION COEFFICIENTS BETWEEN VARIOUS SOIL "CONSTANTS" OF 53 QUEBEC SOILS

Column I contains the simple correlation coefficients; column II gives the partial correlation coefficients. The variables are as follows:

A Organic carbon, %
B Loss on ignition, %
C Clay, %
D Silt, %
E Moisture content at the sticky point, %
F Moisture taken up at 50% relative humidity, %
G Pore space, %
H Heat of wetting, cal. per gm.
J Volume expansion, %
K Maximum moisture taken up, %
L = B − 1.724A
M Index of texture
* Significant, $P = 0.05; r > 0.295$
** Highly significant, $P = 0.01; r > 0.381$

Pair	I	II	Pair	I	II	Pair	I	II
AB	.961	.860**	CG	.272	±.119	GJ	.609	.295*
AC	−.104	.229	CH	.211	.210	GK	.768	.386**
AD	−.193	−.131	CJ	.426	.431**	HJ	.689	.362*
AE	.928	.404**	CK	.034	−.027	HK	.763	.290
AF	.688	−.616**	DE	−.092	.285	JK	.614	±.037
AG	.612	−.080	DF	−.124	−.331*	MA	.885	—
AH	.642	.196	DG	.062	.290	MB	.872	—
AJ	.535	.120	DH	−.025	.178	MC	.197	—
AK	.918	.164	DJ	−.113	±.113	MD	.010	—
BC	−.108	−.333*	DK	−.084	.081	ME	.979	—
BD	−.214	−.029	EF	.830	.624**	MF	.841	—
BE	.913	−.196	EG	.714	−.188	MG	.756	—
BF	.772	.543**	EH	.706	−.356*	MH	.730	—
BG	.685	.387**	EJ	.566	.038	MJ	.629	—
BH	.667	− 165	EK	.972	.700**	LA	−.053	—
BJ	.507	−.094	FG	.795	.136	LC	− 024	—
BK	.900	− 112	FH	.775	.348*	LD	−.092	—
CD	.208	.256	FJ	.572	−.118	LF	− 386	—
CE	.004	±.165	FK	.812	−.182	LG	.292	—
CF	.251	.407**	GH	.778	±.058			

The values of the simple correlation coefficients in Table VI range from the high value of 0.979, which is the simple correlation between moisture content at the sticky point and the index of texture, to negligibly small or non-significant values. In 12 pairs of variables, r is greater than 0.800, and in seven of these, r is greater than 0.900.

It is clear that some of these high correlations cannot be attributed to any causal relation between the two variables in question, but rather to dependence upon one or more other variables. To study this dependence in more detail, the partial correlations have been calculated for all the variables except L and M. The partial correlation coefficients, also given in Table VI, bring out the extent of the association between each pair of variables independent of the accompanying variation in the other variables. As tested by the usual criterion for significance, 16 coefficients are found to be significant, and of these, ten are highly significant.

It will be observed that the partial correlation coefficient between sticky point and clay, after elimination of the effects of the other variables, is now found to be non-significant. It is apparent, therefore, that the significant

negative correlation given in Table V was due to the fact that an insufficient number of variables had been used in the calculation.

The variable showing significant partial correlation with the greatest number of others is the moisture taken up at 50% relative humidity. This property is correlated positively with the percentage of organic carbon, the percentage of clay, the moisture at the sticky point, and the heat of wetting. It is negatively correlated with the loss on ignition and the percentage of silt. Table VII has been prepared to illustrate the relative number of soil properties showing significant partial correlations with each other.

TABLE VII

SOIL PROPERTIES WHICH SHOW SIGNIFICANT PARTIAL CORRELATIONS WITH EACH OTHER

Variable	Positive correlations	Negative correlations
Organic carbon, %, (A)	B, E	F
Loss on ignition, %, (B)	A, F, G	C
Clay, %, (C)	F, J	B
Silt, %, (D)	—	F
Moisture content at the sticky point, %, (E)	A, F, K	H
Moisture taken up at 50% relative humidity, %, (F)	B, C, E, H	A, D
Pore space, %, (G)	B, J, K	—
Heat of wetting, cal. per gm. (H)	F, J	E
Volume expansion, %, (J)	C, G, H	—
Maximum moisture taken up, %, (K)	E, G	—

On the basis of the facts shown in Tables VI and VII, it seems reasonable to select, as a first approximation, organic carbon, loss on ignition, clay, and silt as independent variables, the others being dependent upon these and possibly other properties, at present undefined. As there is strong association between organic carbon and loss on ignition (partial correlation 0.860), it is doubtful whether both these should be considered as independent variables. Moreover, upon calculating the regression equation for loss on ignition (B) as a function of organic carbon (A), clay (C), and silt (D), the following expression is obtained:

$$B = 1.50A - 0.00123C - 0.0220D + 3.17$$

in which the coefficient of A is highly significant and contributes more than 96% of the total variation in B. For this reason, regression equations have been worked out for the other soil properties in terms of (i) organic carbon, clay, and silt, (ii) loss on ignition, clay, and silt, and (iii) organic carbon, loss on ignition, clay, and silt. These are included in the first 19 equations of Table VIII.

For each of the regression equations just mentioned, the multiple correlation coefficient (R) has been calculated, and the value included in Table VIII. It may be observed that these coefficients are comparatively large, *i.e.*, the

equations predict the values of the independent variables with good accuracy. Furthermore, it appears that the three soil properties, clay, silt, and organic carbon, (or loss on ignition), when used as independent variables, will generally produce almost as high a value of R as the inclusion of eight or nine variables. In other words, the three properties mentioned are the important properties and they determine all the others to a very large extent.

TABLE VIII

REGRESSION EQUATIONS FOR PHYSICAL PROPERTIES OF QUEBEC SOILS

A Organic carbon, %
B Loss on ignition, %
C Clay, %
D Silt, %
E Moisture content at the sticky point, %
F Moisture taken up at 50% relative humidity, %
G Pore space, %
H Heat of wetting, cal. per gm.
J Volume expansion, %
K Maximum moisture taken up, %
L = B − 1.724A
R Multiple correlation coefficient

Equation number	Regression equation	R
1	B = 1.497A −0.00123C −0.0220D + 3.17	.936
2	E = 5.99A +0.092C +0.208D +18.2	.935
3	F = 0.356A +0.0262C −0.0119D + 1.62	.754
4	G = 1.45A +0.113C +0.123D +44.6	.710
5	H = 0.509A +0.0034C +0.0168D + 2.44	.702
6	J = 0.967A +0.143C −0.085D + 8.41	.729
7	K = 8.33A +0.170C +0.292D +28.0	.930
8	E = 3.58B +0.091C +0.261D + 9.30	.923
9	F = 0.247B +0.0267C −0.0043D + 2.28	.834
10	G = 0.982B +0.114C +0.153D +41.2	.783
11	H = 0.321B +0.00340C +0.0239D + 1.50	.728
12	J = 0.556B +0.143C −0.080D + 7.20	.708
13	K = 4.97B +0.168C +0.363D +15.7	.914
14	E = 4.10A +1.19B +0.093C +0.234D +14.7	.940
15	F = −0.356A +0.451B +0.026C −0.0020D + 0.30	.856
16	G = 3.90A −1.53B +0.114C +0.162D +47.4	.632
17	H = 0.00636A +0.318B +0.0034C +0.024D + 1.51	.728
18	J = 1.11A −0.90B +0.144C −0.087D +14.3	.725
19	K = 6.00A +1.47B +1.71C +0.325D − 9.33	.933
20	F = 0.372A +0.0266C −0.0018D +0.531L + 0.21	.868
21	G = 1.50A +0.114C +0.158D +1.86L +39.7	.791
22	F = −0.595A +0.270B +0.0147C −0.027D + 0.095E +0.0184G +0.189H −0.0167J − 0.0178K −1.39	.957
23	K = 1.63A −0.571B −0.0106C −0.071D + 1.10E −1.85F +0.67G +1.29H + 0.062J −9.30	.984

It is at first surprising to find, in regression equation No. 15 for F (moisture taken up at 50% relative humidity), that the highly significant coefficient of A (organic carbon) has a negative sign; the same is true of the highly significant coefficient of B (loss on ignition) in equation No. 16 for G (pore space). This must not be interpreted to mean that as the organic carbon content decreases, moisture taken up at 50% relative humidity will increase. Neither does it

follow that pore space decreases with an increase of loss on ignition. The opposite is, in fact, true. The explanation lies in the association which exists between the two variables, loss on ignition and organic carbon. A possible method of separating the two effects is as follows: assume that loss on ignition consists of two parts, (*a*) organic and (*b*) non-organic matter. If, as usual, the percentage of organic matter is considered to be 1.724 times as great as the percentage of organic carbon, we may calculate for each soil sample a new variable (L), the loss on ignition of material not organic, thus:

$$L = B - 1.724A,$$

which may now be treated like the other variables. When this new variable is used to replace loss on ignition in the regression equations, we find that the negative signs disappear from the equations for F and G. The resulting equations are Nos. 20 and 21 n Table VIII. This confirms the c nclusion tha the minus signs, which appear before A or B when both are used together, are due to the high association which exists between the two variables.

To examine the situation when a large number of soil properties are introduced together, the regression equations have been worked out for each of ten variables (A . . . K) in terms of the others. The results for F and K, the two which are most highly correlated with the others, are included in Table VIII to illustrate the type of result which is obtained.

Not only do these calculations supply the regression equations which express one chosen variable as a function of several others, but, following the method of Wallace and Snedecor, it is also possible to assign the weights to be attached to each of the variables and to calculate the percentage contribution of each variable to the others. Moreover, the errors in the estimates and significance of the results can be determined in all cases. This has been done, and the results are included in Table IX.

The numbers in Table IX represent the percentage contributions to the variable leading the row from the respective variables heading the columns. The third line, for example, implies that when loss on ignition is taken as the dependent variable, then the relative weights to be assigned to the independent variables organic carbon, clay, and silt are 96, 1, and 3% respectively. The first of these three values was found to have a standard error of 5.5, hence it is marked highly significant. The other two values are not significant.

The main conclusions which may be drawn from Table IX are as follows:

(i) There is very close agreement (for any particular variable) between the percentage contribution due to organic carbon or to loss on ignition, provided only one of the two variables is included in the calculation.

(ii) Organic material, measured either as organic carbon or loss on ignition, is of much greater relative importance than clay or silt. The figures indicate that, on the average, organic matter contributes between two and three times more than clay does to the dependent soil properties.

(iii) Silt shows little or no significant contribution to the other measured soil properties.

(iv) The relative contributions to moisture taken up at 50% relative humidity and to pore space from organic matter, clay, and non-organic material lost upon ignition are in the approximate ratio 7 : 3 : 4.

(v) Moisture content at the sticky point and maximum moisture taken up by the soil are dependent almost entirely upon organic material.

(vi) In no instance is clay relatively more important than organic material. This is contrary to the observations of Keen and Coutts, who found that the moisture content at 50% relative humidity was controlled largely by the clay content.

All the above observations point to the importance of the organic material in these soils in determining their physical properties. It is also evident that, as far as quantitative prediction of the dependent soil properties is concerned, organic carbon and loss on ignition are about equally useful. The latter is a much simpler determination to make. Thus, in any systematic examination of samples with a view to classification, and where time and effort must be economized, it appears that a determination of loss on ignition should be included.

TABLE IX

RELATIVE DEGREES OF ASSOCIATION BETWEEN SOIL PROPERTIES IN PERCENTAGE

–	A	B	C	D	L	E	F	G	H	J	K
F	−28**	21**	4**	−3*	—	28**	—	1	7**	1	7
K	12	7	1	1	—	53**	7	11**	7*	1*	—
B	96**	—	1	3	—						
E	85**	—	8	7	—						
F	66**	—	29**	5	—						
G	60**	—	29**	11	—						
H	68**	—	27*	5	—						
J	48**	—	43**	9	—						
K	84**	—	10*	6	—						
E	—	84**	8	8	—						
F	—	70**	28**	2	—						
G	—	61**	26**	13	—						
H	—	67**	26**	7	—						
J	—	47**	44**	9	—						
K	—	82**	10	8	—						
E	57**	28	8	7	—						
F	−28**	59**	13**	0	—						
G	52**	−34**	9**	5	—						
H	1	66	26**	7	—						
J	48	6	38**	8	—						
K	59*	24	10*	7	—						
F	49**	—	21**	1	29**						
G	46**	—	21**	10	23**						

Legend

A Organic carbon
B Loss on ignition
C Clay
D Silt
E Moisture at sticky point
F Moisture at 50% relative humidity
G Pore space
H Heat of wetting
J Volume expansion
K Maximum moisture
L = B − 1.724A

** Highly significant P = .01
* Significant P = .05

Summary

Physical properties of samples from different horizons and from different regions show the expected large range of variation.

The pipette and hydrometer methods of mechanical analysis, though generally in agreement, sometimes exhibit large discrepancies which apparently depend on the type of soil studied.

There is high correlation, both simple and partial, between many of the soil properties studied.

By means of regression equations, the dependence between the different soil properties is determined, the independent variables being sand, silt, clay, and organic matter, (or loss on ignition).

When loss on ignition is divided into (i) organic and (ii) inorganic material loss, then the relative contribution to several of the dependent soil properties from (i), (ii), and clay are in the approximate ratio 7 : 4 : 3. Thus organic material is much more important than clay in determining the physical properties of the soils studied.

Acknowledgments

It is a pleasure to acknowledge help from the following: Messrs. H. L. Fletcher and A. J. Sutherland, who did a large part of the analytical work on the virgin soils; Dr. H. J. Atkinson, who collected some of the samples; Dr. R. R. McKibbin, whose advice in selecting, collecting, and classifying samples has been invaluable; and Dr. M. L. Rowles, who assisted in the calculation and interpretation of results.

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AN ANNOTATED LIST OF THE DIPTERA (FLIES) OF ALBERTA[1]

BY E. H. STRICKLAND[2]

Importance of Flies

The Order Diptera is one which does not make a very great appeal to the average collector of insects. Vast numbers of species are very similar in appearance and few of those which occur in Canada are sufficiently striking in color or in appearance to attract the interest of an amateur.

For this reason the regional distribution of the flies which inhabit this Dominion is very imperfectly known. This is a serious handicap in connection with many problems of great importance to agriculture and to the health of man and animals. Members of the Order Diptera have a more varied influence upon human welfare than do those of any other Order of insects. Comparatively few feed directly upon living vegetation, though among these are included such serious pests as leather jackets, Hessian flies, fruit flies, and root maggots. On the other hand, to this Order belong many species of the utmost value to the field husbandman. Nearly all of the species in certain families live as parasites or predators on plant-feeding insects. To the family Tachinidae, for instance, must be attributed most of our immunity from severe and continued losses from many species of injurious caterpillars. Other species of flies constitute the most effective biological factor in the control of grasshopper populations. Still others play a most important part in reducing the numbers of plant lice. In addition, many prey upon their blood-sucking relatives and help to hold their numbers in check although, it must be admitted, not always with complete success.

Human interest in the manifold activities of flies undoubtedly centres around those species which, at some stage in their development, feed on the blood of man and livestock. Not only do they cause serious annoyance and pain by their methods of extracting blood, but many of them are also capable of transmitting fatal diseases while so doing. One has but to recall such human fly-borne diseases as malaria, sleeping sickness, or yellow fever to realize the part that disease-transmitting flies have played in the destiny of nations. To these must be added the contaminative diseases spread by houseflies and their associates.

[1] *Manuscript received January 18, 1938.*

[2] *Professor of Entomology, University of Alberta, Edmonton, Alberta.*

Finally, we should mention the direct attacks which are made by the larvae of certain flies on the flesh of man and livestock. Myiasis, the infestation of wounds by fly larvae, is becoming increasingly frequent among inhabitants of Alberta, while bot flies of horses, cattle, and sheep are a constant drain on the profits of animal husbandmen.

Tribute must, however, be paid to those fly larvae which have been brought into our province occasionally, in order that they may assist in the cure of bone and other human diseases. All of the species which have been thus employed belong to the native fauna of Alberta. The demand for their employment is, fortunately, not sufficient to warrant the expense entailed in raising "surgical maggots" locally.

The University of Alberta Insect Collection

During the past fifteen years an attempt has been made, at this University, to compile a complete list of all species of insects which have been recorded as occurring within the confines of the province.

With this object in view, extensive collections have been made annually, and records of additional captures have been obtained from other sources, particularly from the Dominion Entomological Laboratory at Lethbridge.

Many specialists, both in Canada and the United States, have generously examined and named material in the University collection. Without their help the compilation of this list would not have been possible; we take this opportunity to thank them for their invaluable assistance.

In addition to extensive collecting, all available literature has been searched for published records of insects which have been captured in Alberta. Such Canadian publications as the Canadian Entomologist and the Entomological Record naturally have yielded a large number of records, but many which have never appeared in Canadian literature have been found in journals published in the United States.

Species of Diptera Captured in Alberta

The card catalogue of the University of Alberta insect collection shows that nearly fourteen hundred species of flies have been authoritatively determined as belonging to the Albertan fauna. In addition to these, we possess series in several Families in which we have been unable to have determinations made by any specialist. In a number of instances we have been able to name many of the species ourselves, with the aid of the literature and of material from elsewhere which had been classified by specialists. We feel confident that the collection already contains two or three hundred additional species which cannot be named, under existing conditions.

As we have inferred, there are no amateur collectors of Diptera in Alberta. Apart from accounts in the literature, we have practically no records other than those of captures made by people who are associated with this University. As yet, no attempts have been made to collect flies in the less accessible

areas in the northern part of the province. The number of species which are represented by one or two specimens only is an indication that more intensive and extensive collecting in this province should greatly increase the record of captures which are listed here.

We believe, however, that the list is more complete than that of the other prairie provinces would be; it has been compiled as an initial contribution to the very imperfectly known Dipterous fauna of this part of Canada.

Ecological Areas in Alberta

In recording localities of captures, it is the usual custom to give the name of a town or village in the vicinity of which the insects were taken. Many of the villages near which collections have been made are so small that residents in other parts of the province may be unaware of their location, or of their existence. Such records, therefore, are of very little value. The province can, however, be divided into a number of moderately well-defined ecological areas.

The southeast portion lies in the Transition Zone of the Austral Region. It is typically a short-grass "prairie" country, adapted to the production of hard spring wheat.

At the extreme southeast of this Zone there is an intrusion of the Cypress Hills, in which the flora and fauna closely resemble those of the Rocky Mountains in the southwest of the province. They differ considerably from those of the mountainous regions further north.

The remainder of the province lies in the Boreal Region and is almost entirely in the Canadian Zone, though it merges into a Mountainous Zone in the west through a foothill area, and into the Hudsonian Zone in the extreme north.

Variations in precipitation further divide the province into a series of dry areas in the east, as opposed to more humid western areas.

The soil is moderately uniform in the southeastern areas (Transition Zone); elsewhere it is so variable that any attempt to subdivide areas of prevailing vegetation and precipitation, on the basis of soil types, would necessitate the definition of over one hundred such areas. The flora is similar throughout each of the large northern areas outlined on the map (Fig. 1), though naturally it varies locally on the smaller areas of diverse soil. This variation is not as great as might be anticipated, since with the exception of part of area 15 comprising the "Peace River District", all northern soils are grouped into what are known as "Gray wooded soils". Throughout this vast territory nearly all the soluble chemicals have been leached out of the soil, whatever its physical texture may be.

Insect species which have been taken only in a particular locality in these areas are recorded as "12 sandy", "15 muskeg", etc.

The areas, as outlined, have been established with the assistance of Dr. E. H. Moss, of the Department of Botany, and of Dr. F. A. Wyatt, of the

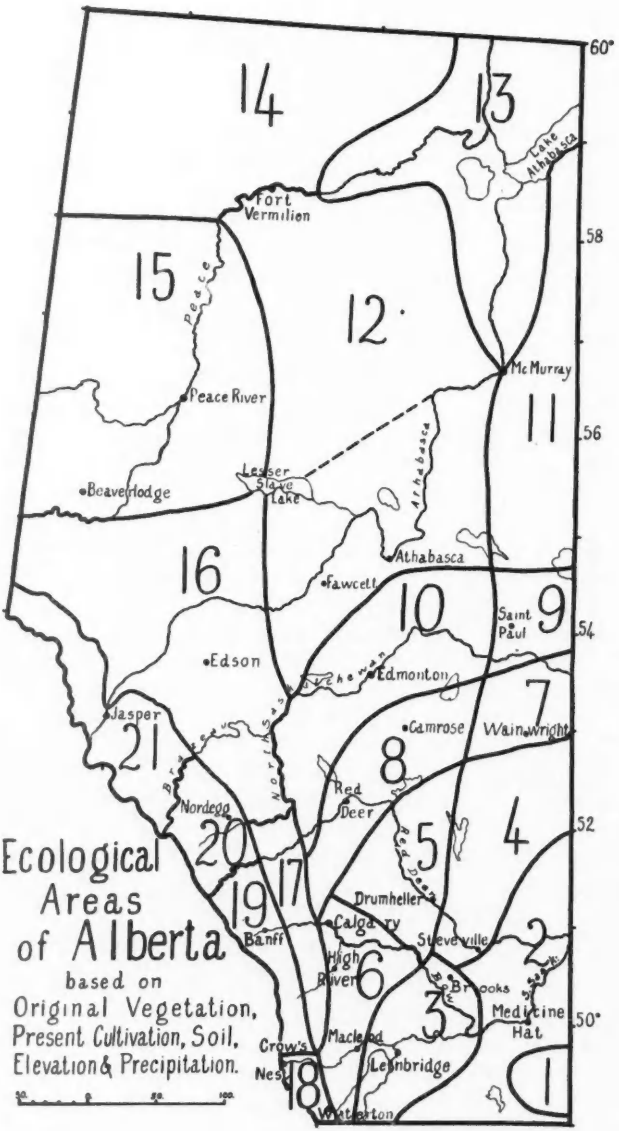
Ecological
Areas
of Alberta
based on
Original Vegetation,
Present Cultivation, Soil,
Elevation & Precipitation.
60°
58
56
54
52
50°
14
13
15
12
11
16
10
9
21
8
7
20
19
17
6
5
4
3
2
1
18
Fort Vermilion
Peace River
McMurray
Beaverlodge
Athabasca
Fawcett
Edson
Edmonton
Saint Paul
Jasper
Camrose
Wainwright
Nordegg
Red Deer
Drumheller
Calgary
Banff
Stevesville
High River
Brooks
Medicine Hat
Crow's Nest
Macleod
Lethbridge
Waterton
Lesser Slave Lake
Lake Athabasca

FIG. 1

Department of Soils. The compiler has had to introduce a number of compromises between such areas as would be defined entirely on botanical considerations on the one hand, and on edaphic considerations on the other.

In computing rainfall, the "Long Time Average Annual Precipitation" chart published by the Searle Grain Co., has been utilized. Any precipitation (chiefly snowfall) between Nov. 1 and March 31 is not included in the chart. Most of this constitutes "run-off" and has little biological significance, except in so far as it may increase the breeding areas for aquatic larvae in the spring, and protect the underlying soil from intense freezing during the winter. Generally speaking, areas in the Transition Zone are bare for the greater part of the winter, whereas elsewhere the ground is covered with a foot or more of snow from early in November till the middle of March.

A brief description of each of the 21 selected areas is as follows:—

TRANSITION ZONE

1. *Cypress Hills*

Vegetation:— About 50% forested; lodgepole pine, spruce, aspen and willow. Remainder; long grass. Very little cultivation.

Elevation:— Up to 4,500 ft.

Soil:— Very dark brown. Summit of hills never glaciated.

Rainfall:— 10–11.5 in.

Remarks:— Flora and fauna are very similar to those of Waterton Area, No. 18. No intensive insect collections have been made here.

2. *Southern Prairie (Dry) (Medicine Hat)*

Vegetation:— Short grass. A few poplars in river bottoms. Cactus and sage in driest localities. Crops: chiefly grain. Much deserted land, which has grown up to mustard or Russian thistle.

Soil:— Fine brown clay, inclined to be sandy in eastern half.

Rainfall:— Less than 10 in.

Remarks:— Fauna near Medicine Hat includes scorpions, solpugids, white ants, horned toads and rattlesnakes. Nowhere else, east of the Rocky Mountains, do these forms extend into Canada. Little insect collecting in this area except in the vicinity of Medicine Hat.

3. *Southern Prairie (About 50% Irrigated) (Lethbridge)*

Resembles Area No. 2. Vegetation on dry areas similar, irrigated parts carry a greater variety of crops, among which alfalfa and beets predominate. Soil a little heavier.

Remarks:— Extensive collections of insects have been made in this area, particularly around Lethbridge.

TRANSITION ZONE—*concluded.*

4. *Northern Prairie (East) (Vermilion)*

Vegetation:— Short to moderately long grass. Much deserted land. Crops: almost entirely grain.

Soil:— Dark brown loam.

Rainfall:— Less than 10 in. Very light in eastern half.

Remarks:— Little insect collecting. The "badlands" of the Red Deer River are in the southwest corner of this area, near Steveville; but no collections have been made here to date.

5. *Northern Prairie (West) (Drumheller)*

Vegetation:— Moderately long grass. Crops: grain.

Soil:— Heavy clay "gumbo" to dark brown loam.

Rainfall:— 10–11.5 in.

Remarks:— Very little insect collecting except near Drumheller.

6. *Northern Prairie (Southern Extension) (Calgary)*

Vegetation:— Moderately long grass, occasional groves of willow and aspen. About 50% under cultivation. Crops: grain and hay.

Soil:— Dark brown loam.

Rainfall:— 10–11.5 in.

Remarks:— Spasmodic insect collecting has been conducted around Calgary, little elsewhere.

INTERMEDIATE BETWEEN TRANSITION AND CANADIAN ZONES

7. *Parkland (East) (Wainwright)*

Vegetation:— About 30% wooded; aspen and willow groves. Remainder; moderately long to short grass. Crops: grain.

Soil:— Dark brown loam, with large areas of almost pure sand.

Rainfall:— Less than 10 in.

Remarks:—Few insects have been collected here; chiefly in the sand-dune country.

8. *Parkland (West) (Red Deer)*

Vegetation:— Originally about 50% wooded; mainly aspen. Remainder; long grass. Now about 70% cleared. Crops: grain and hay.

Soil:— Dark brown loam.

Rainfall:— 10–13 in.

Remarks:— Scattered insect collections have been made throughout this area, most intensively a few miles west of Red Deer.

CANADIAN ZONE

9. *Poplar (East) (Saint Paul)*

Vegetation:— Originally balsam poplar, aspen, and willow, with some spruce. Less than 50% cleared. Crops: chiefly oats.

Soil:— Black loam.

Rainfall:— About 10 in.

Remarks:— Practically no insect collections have been made here.

10. *Poplar (West) (Edmonton)*

Vegetation, as No. 9, but with considerable stands of spruce and pine locally. About 70% cleared. Crops: largely wheat and oats, some hay.

Soil:— Black loam, with a high humus content.

Rainfall:— Over 13 in.

Remarks:— Insects have been collected intensively in this area, particularly in the vicinity of Edmonton and around several lakes further west.

11. *Mixed Forest with Eastern and Sub-arctic Intrusions*

Vegetation:— Aspen, balsam poplar, spruce, jack pine, balsam fir, tamarack, willow, birch, and alder.

Soil:— Gray wooded, with extensive areas of sand.

Rainfall:— Probably 10–11.5 in. No complete records.

Remarks:— This area is not well known. No insect collections have been made here.

12. *Mixed Forest, with Cordilleran (Rocky Mountain) Intrusions (Fawcett)*

Vegetation:— Chiefly forested with aspen, balsam, poplar, spruce, pine, etc. Numerous lakes and large areas of muskeg. A little cultivation in the south. Crops: chiefly oats.

Soil:— Gray wooded, very variable in texture.

Rainfall:— 11.5 to over 13 in.

Remarks:— In the present state of our knowledge there appear to be no factors on which this large area can be subdivided. On the map we have inserted a broken line to divide it, provisionally, into a northern and a southern "sub-area".

Insects have been collected, in rather small numbers, at a few places to the south and east of Lesser Slave Lake, particularly around Fawcett. None have been taken in the northern sub-area.

CANADIAN ZONE—*concluded.*

13. *Mackenzie Lowlands*

Vegetation:— Mixed forest, as in No. 11, with more numerous Alpine-arctic species. Long grass and sedges in open spaces. No cultivated land.

Soil:— Incompletely surveyed, all gray wooded.

Rainfall:— No record, probably around 13 in.

Remarks:— Only about a dozen Dipterous insects have been received from this area.

14. *Mixed Forest with Some Parkland, and Alpine-arctic Intrusions*

Vegetation:— Similar to Nos. 12 and 15. No cultivation.

Soil:— Incompletely surveyed, all gray wooded.

Remarks:— This country is not well known. No insect collections have been made here.

15. *Mixed Forest and Parkland (Beaverlodge)*

Vegetation:— Large mixed forest areas interspersed with long-grass open plains. Crops: chiefly grain and hay.

Soil:— About 10–15% black loam; remainder gray wooded, with scattered patches of sand.

Rainfall:— 10–13 in.

Remarks:— Insects have been collected moderately intensively in the cultivated parts of the Peace River District.

FOOTHILL ZONE

16. *Foothills (Northern)*

Vegetation:— This is an extensive area in which the flora is intermediate between that of the northern Rocky Mountains and the mixed forest of northern Alberta. Much of this area is incompletely surveyed. In a small portion of the eastern half some grain and hay are produced.

Soil:— Gray wooded. Believed to be very variable.

Rainfall:— Over 13 in.

Remarks:— No insect collections have been made in this area.

17. *Foothills (Southern)*

Vegetation:— Aspen, spruce, lodgepole pine, willow, with open prairie southward.

Soil:— Gray wooded in northern portion, dark brown to black in south.

Rainfall:— 13 in. in northern part to less than 10 in. in south.

Remarks:— This is possibly the least uniform area of those selected, even though it is one of the smallest. Very few insects have been collected here.

MOUNTAIN ZONE

The four areas into which this zone has been divided each includes a district in which moderately intensive insect collections have been made.

Vegetation:— This naturally varies greatly with the altitude of the montane, submontane, subalpine and alpine territory, also with topography, rock and soil. Montane territory is dominated by lodgepole pine and white spruce. Douglas fir is locally abundant. Subalpine territory is characterized by Engelmann spruce, alpine fir, and other conifers, as well as by mountain heaths.

From Area 18 to Area 21 there is a gradual and irregular replacement of southern and western species by certain boreal and arctic species. The same characteristics appear to apply to the insect fauna.

18. *Southern Rocky Mountain (Waterton and Crow's Nest Pass)*

Vegetation:— Strong intrusions of southern and western species. These extend to about the northern limits of this area.

Soil:— Contains a relatively higher percentage of lime than does that of the more northern mountain areas.

Rainfall:— Over 13 in.

Remarks:— Intensive collections have been made in Waterton Park, at the extreme south of this area. Smaller collections from Crow's Nest Pass appear to be similar in composition.

19. *Central Rocky Mountain (Banff)*

Vegetation:— Typical for that of the Mountain Zone described above, with few southern or arctic intrusions.

Soil:— Very variable in texture, all gray wooded.

Rainfall:— Over 13 in.

Remarks:— Insect collections have been made at Banff, and to a lesser extent at Lake Louise. Elsewhere the fauna is practically unknown.

20. *North Central Rocky Mountain (Nordegg)*

Vegetation:— Similar to that of No. 19. Among the grasses are several species which appear to be rather typical of the Labrador flora. Mr. Kenneth Bowman, who has collected Lepidoptera in this area for many years, has taken a number of species in this Order which also were formerly considered to be peculiar to the Labrador fauna also.

Soil and Rainfall:— As in No. 19.

Remarks:— Small collections of Diptera have been made in this area in the immediate vicinity of Nordegg.

MOUNTAIN ZONE—*concluded.*

21. *Northern Rocky Mountain (Jasper)*

Vegetation:— As in Nos. 19 and 20, but with strong intrusions of arctic and boreal species.

Soil and Rainfall:— As in No. 19.

Remarks:— Little insect collecting has been accomplished at Jasper to date. Practically no flies have been received from here.

Collections of Diptera have not been made at a distance of more than about 50 miles from the town named (in brackets) in the above headings. Occasional specimens, received from elsewhere in these areas, have invariably belonged to species which have been taken in the neighbourhood of these towns. Should it be desired to make reference to a definite locality, in referring to any particular capture, the name of the town can safely be employed as an alternative to the number of the Area in which is is located.

Explanation of Terms Employed in This List

All species which are represented in the University of Alberta collection are marked with an asterisk (*). Following the name of each such species are given the initials of the authority who made the determination.

The full names to which these initials refer are as follows:—

J.A. The late J. M. Aldrich, U.S. National Museum, Washington.
C.A. C. P. Alexander, Massachusetts Agricultural College, Amherst.
J.B. J. C. Bequaert, School of Tropical Medicine, Harvard University.
F.C. F. R. Cole, Redlands, California.
C.C. C. H. Curran, American Museum of Natural History, New York.
C.F. C. L. Fluke, University of Wisconsin, Madison, Wis.
D.H. D. E. Hardy, Brigham Young University, Utah.
E.H. The late E. Hearle, Dominion Entom. Laboratory, Kamloops, B.C.
H.H. H. C. Huckett, Long Island Research Farm, New York.
C.J. The late C. W. Johnson, Boston Natural History Museum, Boston.
F.M. F. O. Morrison, University of Alberta, Edmonton.
R.M. R. B. Miller, University of Alberta, Edmonton.
C.S. C. W. Sabrosky, East Lansing, Michigan.
R.S. R. C. Shannon, Cornell University, Ithaca, New York.
F.S. F. M. Snyder, Minnesota State College, St. Paul, Minn.
A.S. A. Stone, Bureau of Entomology, Washington.
E.S. E. H. Strickland, University of Alberta, Edmonton.
G.S. G. E. Shewell, Entomological Branch, Ottawa.
C.T. C. R. Twinn, Entomological Branch, Ottawa.
G.W. G. S. Walley, Entomological Branch, Ottawa.

No data regarding the authority who made the determination are given with records obtained from the literature, or with those from other sources if the species is not represented in the collection. These are often unknown and the inclusion of the literature references would increase the size of this publication without a corresponding advantage. A few of the records from Lethbridge (Area 3) and from Waterton (Area 18) have been obtained from Mr. H. L. Seamans of the Dominion Entomological Laboratory at Lethbridge, and have not appeared previously in print.

No attempt has been made to give the names of collectors. Nearly all of the species recorded from the University collection have been taken by the compiler. Other collectors who have donated material to this collection are Owen Bryant, the late F. S. Carr (Medicine Hat, Area 2), the late Eric Hearle (Mosquitoes from Banff, Area 19), and a few university students.

Arabic numerals which follow each insect name refer to the Ecological Areas in which the species is known to occur. Roman numerals refer to the months in which the *adults* have been taken.

Thus:— "*Tabanus astutus O.S. (A.S.) 12, 20, 21. VII–VIII." is interpreted as follows:—

"Tabanus astutus O.S. is represented in the University collection, classified by Dr. A. Stone of Washington, D.C. Adults have been taken in Ecological areas 12, 20 and 21, during July and August."

Further, it can deduced from the map that this species occurs in Lesser Slave Lake, Nordegg, and Jasper districts.

"* Epistrophe sexpunctatus Walk. ? (C.C.) . . ." indicates that Dr. Curran doubtfully referred material in our collection to this species.

"* Helina obscurata Mg. (H.H.) (= nasoni) . . . ." indicates that the species has been recorded under both names as occurring in Alberta. In the majority of instances this indicates synonymy, but in some cases it refers to a misidentification of the species on the part of one writer.

PTYCHOPTERIDAE. False Crane flies

* **Ptychoptera** metallica Walk. (C.A.) 10. VII.

On two occasions we have received larvae, probably of this species, which were numerous in spring water piped into buildings.

TRICHOCERIDAE. Winter Crane flies

Trichocera maculipennis Fab. 10. V.

TIPULIDAE. Crane flies

The majority of the species recorded are the result of a very intensive collection made by Mr. Owen Bryant in 1924. These have already been published by Dr. C. P. Alexander in the Canadian Entomologist, Vol. 59, 1927. The comparatively small University collection contains only a few additional records in this Family. Dr. Alexander has, very kindly, examined this collection and has sent us a complete record of Tipulidae which are known to occur in Alberta.

TIPULIDAE—*continued.*

TIPULINAE

Prionocera fuscipennis Lw. 10, 19. V & VII.
* sordida Lw. (C.A.) 10, 12. VI.
* dimidiata Lw. (C.A.) 8, 10. VI–VIII.
* **Nephrotoma** altissima O.S. (C.A.) 2, 3, 5–10, 15, 20. V–VIII.
* erythrophrys Will. (C.A.) 2, 4, 7, 8, 10, 15, 20. V–VII.
* ferruginea Fab. (C.A.) 2, 3, 8, 10. VI–VIII.
pedunculata Lw. 10. VII.
occipitalis Lw. 10. VI–VII.
Tipula pachyrhinoides Alex. 12. VIII.
accurata Alex. 18, 19. VII–VIII.
barbata Doane 10. IX.
subbarbata Alex. "Alberta".
bucera Alex. 19. VIII.
* mainensis Alex. (C.A.) 10, 12. VIII.
triplex Walk. (= umbrosa) 12. VIII.
penobscot Alex. 10. VII.
entomophthorae Alex. 10. VI–VII.
variata Alex. 10. VI–VII.
albertensis Alex. 10. VII.
latipennis Lw. 10. VII.
ingrata Dietz. 10. VII.
appendiculata Lw. 10. VII.
athabasca Alex. 10. VII.
* macrolabis Lw. (C.A.) 10, 20. VII.
* youngi Alex. (C.A.) 8, 10. V–VII.
balioptera Lw. 10. VI–VII.
fultonensis Alex. (= hinei) 10, 12. VI.
canadensis Lw. 10. VI–VII.
* dorsimaculata Walk. (C.A.) (= angustipennis) 2, 3, 6, 10, 19. V–VII.
* serta Lw. (C.A.) 4, 7, 10, 12. V–VI.
senega Alex. 10. V–VI.
fragilis Lw. 12. VIII.
commiscibilis Doane 6. VII.
kennicotti Alex. (= parvemarginata) 6, 10, 12. V–VIII.
sulphurea Doane 10, 19. V–VII.
pendulifera Alex. 12. VIII.
grata Lw. 10. VII.
platymera Walk. 19.
tessellata Lw. 19.

The two preceding records are from the Entomological Record, 1913. They are not included in Alexander's list.

CYLINDROTOMINAE

* **Liogma** nodicornis O.S. (C.A.) 10. VI–VII.

LIMONIINAE

Limonia triocellata O.S. 10, 12. VIII.
sciophila O.S. 19. 5,700 ft. VII.
cinctipes Say 10. VI–VII.
solitaria O.S. 10, muskeg. VI–VIII.
dietziana Alex. (= gracilis) 10, VI.
tristigma O.S. 12. VIII.

TIPULIDAE—*continued.*

LIMONIINAE—*concluded.*

Limonia—*concluded.*
(Rhipidia) maculata Meig. 10, 12. VI–IX.
fidelis O.S. 10. VI–VII.
(Discobola) annulata L. (= argus) 12. VIII.
(Dicranomyia) immodesta O.S. 10, 12. VIII and X.
rostrifera O.S. 12. VIII.
decora Staeg. 12. VIII.
nycteris Alex. 10. VII.
rufiventris neomorio Alex. 10. VII.
halterata O.S. 10. VI–VII.
athabascae Alex. 10. VI.
haeretica O.S. 10. VII.
intricata Alex. 12. VIII.
platyrostra Alex. 12. VIII.
melleicauda Alex. (C.A.) 10. IX.
Helius flavipes Macq. 10. VI.
Elliptera astigmatica Alex. 12. VII.
Dicranoptycha quadrivittata Alex. 19. VII.

PEDICINI

Ornithodes harrimani Coq. 19. 5,700 ft. VII.
Pedicia (Tricyphona) rubiginosa Alex. 19. 6,000–7,000 ft. VII.
constans Doane 12. VIII.
Dicranota montana Alex. 19. VII.
Ula elegans O.S. 10. VI–VII.

HEXATOMINI

Epiphragma fascipennis Say 10. VI.
* **Pseudolimnophila** noveboracensis Alex. (C.A.) 10, 12. VI–VIII.
* inornata O.S. (C.A.) 10, 12. VI.
Phyllolabis lagganensis Alex. 19. VII.
Limnophila poetica O.S. 10, 20. VI–VII.
bryanti Alex. 10. VI.
harperi Alex. 10. VI.
(Phylidorea) platyphallus Alex. 10. VI.
tepida Alex. 19. V–VI.
fuscovenosa Alex. 19. VII.
(Ephelia) aldrichi Alex. 19. VII.
mcdunnoughi Alex. 19, 20. VII.
* **Pilaria** recondita O.S. (C.A.) 10. VI–VIII.
Hexatoma (Eriocera) alberta Alex. 3. VI.

ERIOPTERINI

Neolimnophila ultima O.S. 10, 12, 19. VIII–IX.
Gonomyia filicauda Alex. 19. IX.
(Idiocera) icasta Alex. 19. VI.
Gnophomyia cockerelli Alex. 3. VI.
Rhabdomastix (Sacandaga) subcaudata Alex. 19. VIII.
subfasciger Alex. 19. VII–VIII.
* **Chionea** valga Harr. (C.A.) 10. XI–XII.
This wingless Tipulid is occasionally moderately abundant on the surface of snow around Edmonton.

TIPULIDAE—*concluded.*

ERIOPTERINI—*concluded.*

Chionea nivicola Doane 19. III.
This record is from the Entomological Record, 1910. It is not included in Alexander's list.
* **Helobia** hybrida Meig. (C.A.) 2, 10, 12, 19, 20. IV–X.
Ormosia arcuata Doane 12. VIII.
albertensis Alex. 19. VII.
garretti Alex. 19. VII.
* **Erioptera** villosa O.S. (C.A.) 10. VII.
bryantiana Alex. 10.
* (**Psiloconopa**) manitobensis Alex. (C.A.) 12. VI.
Molophilus soror Alex. 12. VIII.

ANISOPIDAE.

Anisopus punctatus Fab. 6.

BLEPHARICERIDAE. Net-winged midges

Philorus aylmeri Garr. 19. VIII.
Bibiocephala griseus Curr. 20, 21. VI.

SIMULIDAE. Black flies

Simulium arcticum Mall. 19. VII.
decorum Walk. 8. VIII.
hunteri Mall. 19, 21. VIII.
* pictipes Hag. (C.C.) 3. VII.
* venustum Say (C.C.) 2, 10, 15, 18, 21. VI–VIII.
vittatum Zett. "Alberta". VIII.
Prosimulium fulvum Coq. 2, 6, 19. VIII.
pancerastes D. & S. 19. VIII.

CHIRONOMIDAE. Midges

The study of this family has been seriously neglected in Alberta, largely due to the difficulty in preserving specimens during general collecting in all Orders. The following records, therefore, constitute a small percentage of the species which occur here.

* **Crictopus** brunnicans Walley (R.M.) 10. V.
* flavibasis Mall. (R.M.) 10. Bred.
* tremulus L. (R.M.) 10. V.
* **Tanypus** monilis L. (C.C.) 3. VII.
* illinoensis Mall. (R.M.) 10. VIII.
* **Tanytarsus** fatigans Joh.? (R.M.) 8, 10. VI–VIII.
* **Chironomus** barbipes Staeg. (C.C.) 3, 8, 10. V–VIII.
* brachialis Coq. (R.M.) 10. VI–VII.
* dimorphus Mall. (R.M.) 8. VI.
farinalis Walley 3. VI–VIII.
* imperator Walley (C.C.) 3, 10. VII–VIII.
* indistinctus Mall. (R.M.) 8, 10. V–VI.
* modestus Say (C.C.) 3. VII.
* nigricans Joh. (R.M.) 8, 10 VI–VIII.
* plumosus L. (R.M.) 6, 10. V–VIII.
* tentans Fab. ? (C.C.) 3. V.

CHIRONOMIDAE—*concluded.*

* **Chironomus** utahensis Mall. (R.M.) 10. V.
* varipennis Coq. (R.M.) 10. VI.
* viridicollis V.d.W. (R.M.) 10. VII.
* viridis Mcq. (R.M.) 10. V and VIII.

CERATOPOGONIDAE. Biting midges

* **Forcipomyia** cilipes Coq. (G.W.) 3, 10. VII–IX.
This non-biting species has been bred from muskrat dung in large numbers. The adults enter houses freely in late summer.
Ceratopogon cockerelli Coq. 19. VIII.

PSYCHODIDAE. Moth flies

Psychoda prudens Curr. 20. VII.
* severini Tonn. (C.C.) 10. X.
Pericoma alberta Curr. 18. VII.

DIXIDAE.

Dixa centralis Lw. 19. VI.
johannseni Garr. 19.
occidentalis Garr. 19.

CULICIDAE. Mosquitoes

CORETHRINAE Non-biting mosquitoes

* **Chaoborus** crystallina deG. (C.T.) 8, 10, 15. VI–VII.
The larvae of this species, which are predatory on those of biting species, are common in pools in woodlands around Edmonton. The adults are often very abundant in woods.
* punctipennis Say (C.T.) 8. VI–VII.

ANOPHELINAE Malarial mosquitoes

* **Anopheles** maculipennis Meig. (C.T.) 10, 12. IV–VI and X.
In certain years these constitute about 10% of the total mosquito population which enters tents erected near muskeg. There are no authenticated cases of malarial transmission in Alberta.

CULICINAE

* **Aedes** campestris D. & K. (C.T.) 10. VII.
* canadensis Theo. (E.H.) 8, 19. VI–VIII.
* cataphylla Dyar (E.H.) 10, 19. IV–VIII.
Usually the earliest mosquito, with the exception of overwintering forms, to appear around Edmonton.
* cinereus Meig. (E.H.) 6, 8, 19. V–VIII.
* communis deG. (C.T.) 10. V.
curriei Coq. (? = dorsalis) 19. VI.
* dorsalis Meig. (E.H.) 2, 3, 19. VI–VII.
This is a serious pest in irrigated districts.
* excrucians Walk. (C.T.) 8, 10, 19. VI–VII.
* fitchii F. & Y. (C.T.) 10, 19. IV–VI.
* flavescens Müll. (C.T.) 2, 10, 12. IV–VI.
fletcheri Coq. 5, 6, 8. VII–VIII.
* impiger Walk. (E.H.) 8, 10, 19, 20. V–VIII.
* intrudens Dyar (C.T.) 10, 19. V–VII.
* lazarensis F. & Y. (E.H.) 8, 19. V–VIII.

CULICIDAE—*concluded.*

CULICINAE—*concluded.*

Aedes nearcticus Dyar 19.

* nigromaculis Lud. (C.T.) 2, 3, 15. VI–VIII.
This is a serious pest in irrigated districts.

pionips Dyar 8, 19.

prodotes Dyar 19. VII–VIII.

* pullatus Coq. (E.H.) 19. VII.

* punctor Kby. (C.T.) 8, 10, 12, 19. VI–VIII.

* spenceri Theo. (C.T.) 2, 10, 19, 20. VI–VIII.
Larvae of this species are abundant in ditches by roads around Edmonton. Adults extremely numerous in favorable years. Are vicious biters.

* stimulans Walk. (C.T.) 10. V.

* trichurus Dyar (C.T.) 10, 12, 15. V–VI.

* vexans Meig. (E.H.) 3, 6, 8, 10, 19. VI-VIII.
This is, probably, the most widespread and abundant species in the prairie regions of Alberta.

* **Theobaldia** alaskaensis Lud. (E.H.) 6, 10, 19, 20. IV–VII.
Hibernating adults are vicious biters from early in April. Enter houses freely.

dyari Coq. 8. VII.

impatiens Walk. 8, 12. V–VIII.

* incidens Thom. (E.H.) 19. VII.

* inornatus Will. (E.H.) 2, 10, 15, 19. VIII–XI.

* **Culex** tarsalis Coq. (C.T.) 3, 19. VII.

CECIDOMYIDAE. Gall midges

Very little attention has been paid to this Family of minute flies. A small number have been collected in the field, but we have found no specialist who is willing to name them for us. The only named specimens are those which have been bred from readily identified galls.

* **Rhabdophaga** strobiloides Walsh. (C.C.) 3, 10. IV.
Cone gall of willows. Very common.

* **Diarthronomyia** hypogaea Lw. (E.S.) 10. Bred.
"Chrysanthemum midge". First observed in Alberta in 1929. Now widespread in greenhouses.

Phytophaga destructor Say (?) 6.
About 1916, it was recorded at Ottawa, that "flax seeds" had been found in stems of winter wheat from Pincher Creek, Alta. There has been no sign of this insect in subsequent years.

* rigida O.S. (C.C.) 10, II–III. Bred.
Stem gall of willows.

* **Contarinia** virginianae Felt (E.S.) 10, 12. VII.
Forms galls from fruit of choke-cherries.

SCIARIDAE. Dark-winged fungus gnats

* **Eugnoriste** occidentalis Coq. (E.S.) 15. VII.

* **Sciara** caldaria Lint. (C.C.) 2. XII.

* coprophila Lint. (E.S.) 10. IX–III.
A serious mushroom pest around Edmonton.

MYCETOPHILIDAE. Fungus gnats

The University collection contains long series of flies belonging to this Family. We have attempted to name the more characteristic species ourselves since we have found no specialist who is willing to identify material in this Family.

BOLITOPHILINAE

* **Bolitophila** disjuncta Lw. (E.S.) 10. VI.
recurva Garr. 19.

CEROPLATINAE

* **Asindulum** montanum Roed. (E.S.) 10. VIII.
* **Platyura** fascipennis sagax Joh. (E.S.) 12. VI.

MACROCERINAE

Macrocera variola Garr. 19.

SCIOPHILINAE

Mycomya ampla Garr. 19. VII.
* imitans Joh. (E.S.) 10. VIII.
* littoralis Say (E.S.) 10. VII–IX.
* frequens Joh. (E.S.) 10. VIII.
* obliqua Say (E.S.) 10. VIII.
* tantilla Lw. (E.S.) 10. VIII–IX.
* **Sciophila** glabana Joh. (E.S.) 10. VII–VIII.
neohebes Garr. 19.

MYCETOPHILINAE

* **Leia** striata Will. (E.S.) 10, 15. VI–IX.
* winthemii Leh. (E.S.) 10. VIII.
* **Docosia** nitida Joh. ? (E.S.) 10, 12. VI.
* **Exechia** obediens Joh. (C.C.) 10. X.
* **Allodia** bella Joh. (E.S.) 10. V.
* **Dynatosoma** nigrina Joh. (C.C.) 10. V.
* **Phronia** venusta Joh. (C.C.) 10. X.
Mycetophila alberta Curr. 10. V.
* punctata Meig. (E.S.) 15.
* **Sceptonia** nigra Meig. (E.S.) 10. V.

BIBIONIDAE. March flies

* **Hesperinus** brevifrons Walk. (D.H.) 8, 10, 15. VI.
* **Plecia** heteroptera Say (D.H.) 1, 10. V–IX.
* **Dilophus** caurinus L. (C.C.) 18. VII.
* sectus McA. (D.H.) 10. VIII.
serraticollis Walk. 19. IX.
* stigmaterus Say (D.H.) 3, 5, 10. VII–VIII.
* **Bibio** albipennis hirtus Lw. (C.C.) 2, 3, 10, 18. V–VI.
Larvae sometimes excessively abundant in soil which contains much decaying vegetable matter, such as roots of wild roses in recently broken land. Also in manure. Occasionally damage earthed-up celery, and have been found swarming in undug potatoes. Probably not a primary pest of latter.
* carri Curr. (C.C.) 2. V–VI.
fraternus Lw. 3. IV.
* fumipennis Wlk. (D.H.) 8. VII.

BIBIONIDAE—*concluded.*

* **Bibio** holti McA. (D.H.) 8, 10, 18. V–VIII.
obscurus Lw. 19. IX.
simplicis Curr. 19, 20. VII–VIII.
* slossonae Ckll. (D.H.) 10. IX and V.
Adults appear in swarms in woodlands in late autumn.
* tenuipes Coq. (D.H.) 3. V.
* variabilis Lw. (D.H.) 8, 15, 18. VI–VIII.
* xanthopus Wied. (D.H.) 20. VII.

SCATOPSIDAE. Minute black scavengers

* **Aspistes** analis Kby. (C.C.) 15, 19. VI–VII.
Scatopse pygmaea Lw. 3. VII.
* **Rhegoclema** atrata Say (E.S.) 10. X.

STRATIOMYIDAE. Soldier flies

BERIDINAE

* **Beris** annulifera Big. (E.S.) 8, 10. VI–VII.
canadensis Cress. 18. VII.
* viridis Say (E.S.) 10. IV–VI.

CLITELLINAE

Euparyphus latilimbatus Curr. 12, 18. VII.
* limbiventris Will. (C.C.) 2. VI.
* octomaculatus Curr. (E.S.) 8. VI.
quadrimaculatus Cress. 19. V–VI.
* **Nemotelus** arator Mel. (E.S.) 10, 19. VII–VIII.
* canadensis Lw. (C.C.) 3, 9, 19. VI–VII.

STRATIOMYINAE

* **Stratiomys** apicula Lw. (C.C.) 3, 8, 20. VI.
* badia Wlk. (C.C.) 10. VI–VIII.
* barbata Lw. (C.C.) 18, 19, 20. VI–VIII.
* bruneri Joh. (E.S.) 3, 10. VIII.
* laticeps Lw. (E.S.) 12, 18, 19. VII.
* lativentris Lw. (C.C.) 18. VII.
* melanostoma Lw. (C.C.) 20. VII.
* nevadae Big. (C.C.) 2, 6. V–VI.
* normula Lw. (C.C.) 2, 3, 8, 9. VI–VII.
* unilimbata Lw. (E.S.) 3, 8, 12. VI.
* **Odontomyia** hoodiana Big. (C.C.) 10, 19. V–VIII.
* inaequalis Lw. (E.S.) 3. VIII.
* interrupta Oliv. (C.C.) 10. V.
nigrirostris Lw. 2, 19. VII–VIII.
* pubescens Day. (E.S.) 3, 15. VI–VII.
similis Joh. 18.
varipes Lw. 12, 19. VI and IX.
* vertebrata Say (E.S.) 10. VII.
* virgo Wied. (E.S.) 8. 10. VII.

SARGINAE

Pedicella cuprarius L. "Alberta".
* decorus Say (J.J.) 6, 10, 18. VIII.
* viridis Say (C.C.) 2, 3, 6, 10, 18. V–IX.
* **Microchrysa** polita L. (C.C.) 3, 8-10, 12. VI–VII.

COENOMYIIDAE.

* **Arthropeas** magna Joh. (C.C.) 6.

Two or three larvae, which key out in Malloch's tables to *Coenomyia ferruginea*, have been taken from the soil in Edmonton. All have refused to feed on Coleopterous, Lepidopterous, and Dipterous larvae, which were offered to them dead and alive, and they died in captivity.

TABANIDAE. Gad flies, Deer flies, Breeze flies

* **Chrysops** carbonaria Walk. (A.S.) 10. VI.

* discalis Will. (A.S.) 2, 3. VII.

This species, implicated in the transmission of Tularemia, appears to be confined to the driest portion of Alberta. Two or three cases of this disease which have occurred in the northern part of the province do not appear to have been contracted from an insect bite.

* excitans Walk. (A.S.) 12, 14. VI.

* frigida O.S. (A.S.) 10. VI–VII.

* fulvaster O.S. (C.C.) 2. VII.

* furcatus Wlk. (A.S.) 19, 20. VII.

* mitis O.S. (A.S.) 1, 3, 8, 10. VI–VII.

* nigripes Zett. (A.S.) 10. VII.

* pertinax Wlk. (A.S.) 18. VII.

* proclivis O.S. (A.S.) 20. VII.

* **Haematopota** americana O.S. (A.S.) 6, 10. VII–VIII.

This gad fly is rather rare in Alberta, though it is apparently abundant elsewhere on the prairie.

* **Tabanus** astutus O.S. (A.S.) 10, 16, 20. VII–VIII.

* affinis Kby. (A.S.) 3, 16. VI–VII.

* canadensis Curr. (C.C.) 1. VII.

centron Mart. (? = rhombicus) 12, 13. V–VI.

cristatus Curr. 20. VII.

* epistatus O.S. (A.S.) 10, 12. V–VI.

fratellus Will. 19. VIII.

* gracilipalpis Hine (A.S.) 12. VI.

* hirtulus Big. (A.S.) 3, 19. VI.

* illotus O.S. (A.S.) 8, 10, 15. VI.

* laniferus McD. (A.S.) 19, 21. VII–IX.

* lasiophthalmus Macq. (A.S.) 12, 20. VI–VII.

* liorhinus Phil. (A.S.) 10. VIII.

* metabolus McD. (A.S.) 10, 12, 14, 20. V–VI.

* nivosus O.S. (A.S.) 10. VI.

* nudus McD. (A.S. 10, 12, 15. VI.

phaenops O.S. 19, 20. VII.

* reinwardtii Weid. (A.S.) 3, 6. VII.

* rhombicus O.S. (A.S.) 6, 19, 20. VII–VIII.

* osburni Hine (C.C.) 18, 19. VII.

* rupestris McD. (E.S.) 6, 12. VI.

* septentrionalis Lw. (A.S.) 6, 8, 10. VI–VIII.

sonomensis O.S. "Alberta".

* sexfasciatus Hine (C.C.) 16. VII.

trepidus McD. "Alberta".

* typhus Whit. (A.S.) 12, 16. VI–VII.

* zonalis Kby. (A.S.) 16, 19. VII.

* (**Atylotus**) insuetus O.S. (A.S.) 6, 20. VII.

RHAGIONIDAE. Snipe flies

* **Symphoromyia** atripes Big. (E.S.) 18, 19. VII.

This species, with *S. **hirta***, is frequently a serious nuisance in the National Parks of the Rocky Mountains. The bite is not painful but the flies are most persistent in attacking, both in the shade and in the open.

* cinerea Joh. (E.S.) 18. VII.
* hirta Joh. (C.C.) 18, 19. VII.
* johnstoni Coq. (C.C.) 18. VII.
* montana Ald. (C.C.) 20. VII.
pachyceras Will. 19. VII.
* **Chrysopilus** quadratus Say (C.C.) 9, 10, 16. VI–VII.
Ptiolina alberta Leon. 19. VII.

ASILIDAE. Assassin flies

DASYPOGONINAE

* **Comantella** fallei Back. (C.C.) 2. II–III.
rotgeri James. 2. III–V and X.
Nicocles punctipennis Mel. 2. IV.
* **Stenopogon** gratus Lw. (F.C.) 3. VIII.
* inquinatus Lw. (C.C.) 2, 6. VII–IX.
* obscuriventris Lw. (E.S.) 7. VI.
* pumilis Coq. (C.C.) 2. VII.
Neopogon (= **Stichopogon**) argenteus Say. 2. IX.
Lasiopogon aldrichi Mel. 19. VII.
* cinereus Cole (C.C.) 18, 19. VII–VIII.
quadrivittatus Jones 2. V.
* **Eucyrtopogon** albibarbis Curr. (F.C.) 2, 6, 10. IV–VI.
* calcarata Curr. (C.C.) 6, 19. V and X.
* comantis Curr. (C.C.) 2. IV.
* spinigera Curr. (F.C.) 6, 12. V–VI.
Cyrtopogon albitarsis Curr. 18, 19. VII.
albovarians Curr. 19. VII.
* bimacula Wlk. (F.C.) 6, 10, 15, 20. V–IX.
dasyllis Will. 19.
linneotarsus Curr. 19. VIII.
montanus Lw. 19.
nebulo O.S. 19. III.
nugator O.S. 19. VI–VII.
praepes Will. 6, 19.
sansoni Curr. 19. VII.
* vulneratus Mel. (F.C.) 10. VII.
* willistoni Curr. (C.C.) 6, 18, 19. VI–VII.
* **Holopogon** albopilosa Curr. (C.C.) 3. VII.

LAPHRINAE

Pogonosoma ridingsi Cress. 18. VII.
* **Bombomima** colombia Walk. (F.C.) 19. VI.
* insignis Bnks. (C.C.) 10. VII.
partitor Bnks. 19. VII.
* posticata Say (C.C.) 12. VIII.
Laphria aeatus Wlk. 12. VI–VII.
aimites Mtclf. 10. IX.
ferox Will. 19. X.
* gilva L. (C.C.) 9, 19. VII.

ASILIDAE—*concluded.*

LAPHRINAE—*concluded.*

* **Laphria** janus McA. (C.C.) 10, 19. V–VIII.
pubescens Will. 19. VIII.
* sadales Wlk. (F.C.) 20. VII.
xanthippe Will. 19. VI.

ASILINAE

* **Erax** bicaudatus Hine (C.C.) 2, 3. VII–VIII.
* subcupreus Sch. (C.C.) 2. VI.
Rhadiurgus cacopilogus Hine 2. IX.
* **Asilus** auriannulatus Hine (C.C.) 18. VII.
nitidifacies Hine 19. VII.
Machimus antimachus Walk. 3. VII.
* callidus Will. (C.C.) 3, 10, 18, 19. VII.
* erythocnemis Hine (C.C.) 1–5. VII–VIII.
* occidentalis Hine (C.C.) 19. VIII.
* paropus Walk. (C.C.) 10. VII.
* snowi Hine (C.C.) 3. VIII.

THEREVIDAE. Stiletto flies

* **Thereva** cingulata Krob. (F.C.) 18. VII.
* cockerelli Cole (F.C.) 8, 10. VI–VIII.
* duplicis Coq. (F.C.) 1, 6, 8, 10, 15. IV–VIII.
Larvae are very abundant in cultivated fields. It is stated that they feed on wireworms and small cutworms, but we have failed to induce them to attack either.
mcdunnoughi Cole 20. VII.
strigipes Lw. 19.
* **Psilocephala** albertensis Cole (C.C.) 2, 3. IV–VI.
* aldrichi Coq. (F.C.) 1–3, 10, 18. VI–VIII.
baccata Coq. 2. V.
coquilleta Ald. 3. VII.
limata Coq. 18. VII.
* munda Lw. (C.C.) 1, 6, 9, 10, 15, 19. V–VII.

BOMBYLIIDAE. Bee flies

* **Anthrax** analis Say (C.C.) 10. VIII.
Reported to be a parasite of tiger beetles.
* oedipus Fall. (= irrorata) (F.C.) 8, 10, 18. VI–VII.
* plesia Curr. (F.C.) 18. VII.
* varia Fall. (C.C.) 7, 18. VI–VII.
* **Exoprosopa** caliptera Say (F.C.) 3, 10. VI–VII.
* decora Lw. (C.C.) 1—3. VI–VIII.
dorcadion O.S. 18. VII.
* **Thyridanthrax** alpha O.S. (C.C.) 2. IX.
* bigradata Lw. (C.C.) 2. V.
* halcyon Say (C.C.) 2, 10. VII–VIII.
* lateralis Say (C.C.) 1, 3, 6, 10. VI–VIII.
* muscaria Coq. (C.C.) 2. VIII.
* sackenii Coq. (C.C.) 3, 6. VIII–IX.
* salebrosus Paint. (C.C.) 2. VI.
* tegminipennis Say (F.C.) 2, 3. VIII–IX.

BOMBYLIIDAE—*concluded.*

* **Thyridanthrax** willistoni Coq. (C.C.) 2, 3, 6. VII–IX.

The genus *Thyridanthrax* has recently been derived from *Villa* as a valid genus. All the species in our collection were determined as *Villa*. We have placed in the former genus all species represented in the collection which appear to belong there, and have left all doubtful or unseen species in *Villa*.

* **Villa** alternata Say (C.C.) 1, 6, 10. VII–X.
* eumenes O.S. (C.C.) 3. VII.
* fulviana Say (C.C.) 3, 6, 10, 15, 18–20. VII–VIII.
nigricauda Lw. 19. VII.
* hypomelas Mg. (F.C.) 1. VII.
* lepidota O.S. (C.C.) 3. V.
* molitor Coq. (F.C.) 4. VII.
* morio L. (= morioides) (C.C.) 6–10, 18, 20. V–VIII.
* mucorea Lw. 3. VII.
pretiosa Coq. 18. VII.
* sinuosa Wd. (F.C.) 3, 6, 8, 10, 18. VI–IX.
* syrtis Coq. (C.C.) 2. VII.
* **Toxophora** pellucida Coq. (F.C.) 2. VIII.
* **Bombylius** albocapillus Lw. (C.C.) 2, 6, 19. IV–V.
* aurifer O.S. (C.C.) 18. VII.
lancifer O.S. 18. VII.
* major L. (C.C.) 2, 10, 14. IV–V.

This very common species is recorded as a parasite of solitary bees.

pulchellus Lw. 10. V.
* pygmaeus Fabr. (F.C.) 8, 10. V–VI.
* **Anastoechus** nitidulus F. (C.C.) 2, 6, 10. VIII.
Systoechus solitus Walk. 3. VII.
* oreas O.S. (F.C.) 2, 3, 7. VI–VIII.
* vulgaris Lw. (C.C.) 1–5. VII.

The most important predator on the eggs of grasshoppers.

* **Conophorus** nr. nigripennis Lw. (F.C.) 18. VI.
* **Lordotus** gibbus Lw. (C.C.) 2. VIII.

CYRTIDAE. Spider parasites

Dr. F. C. Cole, who has the material from the University collection for identification, states that there are additional species represented.

* **Ogcodes** incultus Lw. (F.C.) 18. VII.
* marginatus Cole (C.C.) 1. VII.
Acrocera bulla West. 2. X.
* convexus Cole (F.C.) 10. VII.
* fasciata Wied. (F.C.) 2, 10. VII.

EMPIDAE. Dance flies, or Balloon flies

A large number of species belonging to this Family are represented in the University collection. During recent years we have failed to find any specialist who is willing to name these for us. We have attempted to name a few which appear to be readily recognized from published descriptions, but the bulk of the collection is unnamed.

EMPIDAE—*concluded.*

HYBOTINAE

* **Hybos** triplex Walk. (E.S.) 10. VI.
* **Ocydromia** glabricula Fall. (E.S.) 10, 15. VI–VIII.
* **Oedalia** ohioensis Mel. (E.S.) 10. VIII.

EMPINAE

* **Hormopeza** bullata Mel. (E.S.) 10. VIII.
nigricans Lw. 19. VII.
Hilaria auripes Curr. 19. VII.
garretti Curr. 19. VI–VII.
granditarsis Curr. 19. VII.
rufopuncta Curr. 19. VII.
* **Hesperempis** mabelae Mel. (E.S.) 10. VI.
* **Empis** brachysoma Coq. (C.C.) 18. VII.
* **Rhamphomyia** flexuosa Coq. (C.C.) 5, 10, 18, 20. V–VII.
This appears to be the most abundant and widespread species in Alberta. The Genus is well represented by other species, however.

HEMERODROMINAE

Clinocera simplex Lw. 19. VIII.

TACHYDROMINAE

* **Tachypeza** clavipes Lw. (E.S.) 15. VI.
* winthemi Zett. (E.S.) 15, 20. VI–VII.
Phoneustica maculipennis Walk. "Alberta" VI–VIII.
* **Platypalpus** aequalis Lw. (C.C.) 3, VI–VII.
pectinator Mel. 19.
perimerus Mall. 3. VI.
* **Drapetis** scissa (E.S.) 10. VI.
(**Eudrapetis**) facialis Mel. 2.

DOLICHOPODIDAE. Long-headed flies

Dolichopus adequatus V.D. 19. VI.
* aeratus V.D. (E.S.) 3, 19. VII.
* affluens V.D. (E.S.) 10. VII.
albertensis Curr. 19. VI–VII.
* albiciliatus Lw.? (C.C.) 3. VII.
* albicoxa Ald. (E.S.) 19, 20. VII–VIII.
* amphericus M. & B. (C.C.) 8, 10, 18. VI–VII.
* barbicauda V.D. (E.S.) 10. V.
* bakeri Cole (E.S.) 8, 19. VI–VII.
* bifractus Lw. (C.C.) 1–3, 8, 20. VI–VIII.
breviciliatus V.D. 19. VIII.
* brevipennis Meig. (C.C.) 3, 8, 15, 19, 20. VI–VII.
* canadensis V.D. (C.C.) 2, 8, 10, 15. VI.
* coloradensis Ald. (E.S.) 10, 19. VI–VII.
conspectus V.D. 3. V.
* discifer Stan. (E.S.) 10, 12, 20. VI–VII.
diversipennis Curr. 20. VII.
* flaviciliatus V.D. (E.S.) 7. VII.
flagellitenens Wheel. 6. VIII.
* frontalis V.D. (E.S.) 10, 20. VII.
* fulvipes Lw. (E.S.) 3, 8, 19. VII.
gratus Lw. 19. V–VI.

DOLICHOPODIDAE—*continued.*

* **Dolichopus** lobatus Lw. (C.C.) 8, 10, 12. VI–VII.
* longicornis Stan. (E.S.) 12. VI.
* longimanus Lw. (E.S.) 8, 10, 12, 15. VI–VII.
maculitarsis V.D. 3. V.
manicula V.D. 19. VII.
* nigricornis Mg. (C.C.) 10. VII.
nigrilineatus V.D. 10, 20. VII.
nigrimanus V.D. 19. VII.
* nudus Lw. (E.S.) 19, 20. VII–VIII.
* obcordatus Ald. (C.C.) 3, 8, 10, 19, 20. V–VII.
* omnivagus V.D. (E.S.) 10, 19. VII–VIII.
paluster M. & B. 19. V.
pernix M. & B. 3, 19. VI–VII.
pilatus V.D. 19. VIII.
* plumipes Scop. (E.S.) 3, 8, 18. VI–VII.
plumosus Ald. 18. VII.
pollex O.S. 19. VII.
* procerus V.D. (E.S.) 3, 10, 19. VI–VIII.
* ramifer Lw. (C.C.) 2, 3. IV–VI.
* remipes Wahl. (E.S.) 10. VII.
* renidescens M. & B. (C.C.) 3, 8, 10, 15, 19. V–VIII.
* robertsoni Curr. (C.C.) 3. VIII.
* sincerus Mel. (E.S.) 20. VII.
* socius gladius V.D. (E.S.) 8. VII.
* speciosus V.D. (C.C.) 18, 19. VII–VIII.
* splendidulus Lw. (C.C.) 8, 10, 15. VI–VII.
* splendidus Lw. (C.C.) 2, 10, 15. V–VII.
sufflavus V.D. 19.
* stenhammari Zett. (E.S.) 15. VI.
uxorcula V.D. 19. VII.
vanduzeei Curr. 19.
* variabilis gracilis Ald. (F.M.) 10, 19. VII.
Liancalus hydrophilus Ald. 19. IX–X.
* **Medeterus** trisetosus V.D. (E.S.) 18, 19. VI.
Tachytrechus sanus O.S. 18. VI–VII.
Hercostomus unicolor Lw. 18. VII.
* **Neurigona** ciliata V.D. (C.C.) 8, 10. VII.
nigrimanus V.D. 19. VII.
ornatus V.D. 10. VI.
planipes V.D. 18. VII.
* **Scellus** amplus Curr. (C.C.) 3, 18. VII.
avidus Lw. 6.
* filiferus Lw. (C.C.) 1, 6, 18. VI–VII.
* monstrosus O.S. (E.S.) 3. VII.
vigil O.S. 3, 19.
Hydrophorus aestuum Lw. 3. VI.
algens Wheel. 19. VII–IX.
altivagus Ald. 3. VII.
ampullaceus V.D. 19. VIII.
cerutias Lw. 4. VIII.
fulvidorsum V.D. 3.
gratiosus Ald. 3. V.
* purus Curr. (E.S.) 3, 4. VIII.

DOLICHOPODIDAE—*concluded.*

Rhaphium campestris Curr. 19. VII.
crassipes Mg. 19. VIII.
effilatum Wheel. "Alberta".
femoratum V.D. 18, 19. V–VIII
latifacies V.D. 19. VII.
longibara V.D. 19. VI–VII.
spinitarsis Curr. "Alberta".
Diaphorus snowii V.D. 19. VIII.
Parasyntormon emarginicornis Curr. 19. VII.
Chrysotus hirtipes V.D. "Alberta" VI–VII.
Sympycnus cuprinus Wheel. 19. VIII.
marcidas Wheel. 19. VII–VIII.
Pelastoneurus vagans O.S. 3. VI.
* **Argyra** bimaculata V.D. (E.S.) 12. VI.
* robusta Joh. (E.S.) 10. VI.

LONCHOPTERIDAE. Pointed-wing flies

* **Lonchoptera** borealis Curr. (E.S.) 10. VI.
* occidentalis Curr. (E.S.) 10. VI.
* uniseta Curr. (E.S.) 10. IV.

These flies have been swept from rushes near lakes.

PHORIDAE. Hump-back flies

We have about a dozen species in the collection, among which we have identified with a fair degree of certainty, the following:

* **Hypocera** clavata Lw. (E.S.) 10. VI.
* femorata Mg. (E.S.) 8, 10. VI.
* **Gymnophora** arcuata Mg. (E.S.) 10. VII.
* **Megaselia** rufipes Mg. (E.S.) 10, 19. V–VI.
* **Trineura** velutina Mg. (E.S.) 10. V.

PLATYPEZIDAE. Flat-footed flies

Several species in this Family have been taken walking on foliage of bushes near water. We have been unable to find a specialist to name them for us, but two key out rather readily to the following species.

* **Agathomyia** vanduzeei Joh. (E.S.) 10. IX.
* **Callimyia** venusta Snow (E.S.) 12. VI.

PIPUNCULIDAE. Big-headed flies

* **Pipunculus** albofasciatus Hough (E.S.) 15. VI.
exilis Mall. 2.
* houghi Kert. ? (E.S.) 10. VI.
inconspicuus Mall. 2. X.
occidentalis Mall. 2. X.
* stricklandi Curr. (E.S.) 10, 18. VII.
Nephrocerus daeckeri Joh. 10. VI.

SYRPHIDAE. Flower or Hover flies

CERIOIDINAE

* **Cerioides** abbreviata Lw. (C.F.) 10. VII–VIII.

SYRPHIDAE—*continued.*

MICRODONTINAE

Microdon albipilis Curr. 3. VIII.
* cothurnatus Big. (C.F.) 10, 12. V–VI.
* piperi Knab (C.C.) 18. VII.

VOLUCELLINAE

* **Copestylum** caudatum Curr. (C.C.) 2, 3. V–VII.
* **Volucella** bombylans facialis Will. (E.S.) 8, 10, 20. VII–VIII.
* lateralis Joh. (E.S.) 10. VII.
* rufomaculata Jones (C.C.) 6. V.
* satur O.S. (C.C.) 2. VIII.

SYRPHINAE

Chrysotoxum coloradense Green "Alberta".
* derivatum Wlk. (C.C.) (? = ventricosum) 10, 16, 18, 19. VII–VIII.
pubescens Lw. 10. VII.
ypsilon Will. (? = occidentale) 19.
* **Paragus** bicolor Fab. (C.C.) 2, 18. VI–VII.
* tibialis Fall. (C.C.) 2, 3, 6, 20. V.
* **Leucozona** leucorum L. (C.F.) 10. VII.
* americana Curr. (C.C.) 10. VII.
* **Eupeodes** volucris O.S. (C.C.) 1–3, 6. V–VII.
* **Scaeva** pyrastri L. (C.C.) 2, 3, 6, 10, 18, 19. VI–X.
* **Syrphus** amalopus O.S. (C.C.) 18, 19. VI–VII.
* arcuatus Fall. (J.A.) (? = perplexus or lapponicus) 19. VII.
attenuatus Hine 19.
* bigelowi Curr. (C.C.) 10, 18, 20. VII–VIII.
insolitus Osb. 18. VI.
* lapponicus Zett. (C.C.) 18. VII–VIII.
* laxa O.S. (C.C.) 18. VII.
* opinator O.S. (C.C.) 3, 6, 18, 19. V–IX.
* osburni Curr. (J.A.) (? = amalopus) 10, 18. V.
pacifica Lw. "Alberta".
palliventris Curr. 20. VI.
* perplexus Osb. (J.A.) 10, 18. V–VIII.
* rectus O.S. (C.C.) 3, 10, 20. IV and VII.
* ribesii L. (J.A.) 10, 12. V–VIII.
* vittafrons Shn. (C.C.) 10. VIII.
* torvus O.S. (C.C.) 3. V.
* umbellatum O.S. (J.A.) 10. VI.
* venablesi Curr. (= nitens) (C.C.) 6, 10. V and VIII.
* vitripennis Mg. (C.C.) 3, 10. VII–VIII.
* wiedemanni Joh. (C.C.) 3. VII.
* **Epistrophe** albipunctatus Curr. (C.C.) 10. VIII.
contumax O.S. 19. VI–VII.
* fisheri Walt. (C.C.) 10. VIII.
* garretti Curr. (C.F.) 10, 19. VI.
* grossulariae Mg. (C.C.) 18. VII.
* melanis Curr. (C.C.) 18. VII.
nigrifascies Curr. 19. VII.
* rectoides Curr. (C.C.) 18. VII.
* sexpunctatus Walk. ? (C.C.) 10. VII.
* sodalis Will. (C.C.) 18, 19. V–VII.
subfasciatus Curr. 19.

SYRPHIDAE—*continued.*

* **Epistrophe** tenuis Osb. (C.C.) 10. VI.
* **Mesogramma** marginata Say (C.F.) 3, 10, 15. VII.
* **Sphaerophoria** cylindrica Say (C.F.) 3, 8, 10, 12, 15. V–VIII.
* robusta Met. (C.C.) 2, 3, 15, 18. V–VIII.
* **Pyrophaena** granditarsis Forst. (C.C.) 10. VIII.
* **Platycheirus** angustatus Zett. (C.F.) 8, 10. VII.
* erraticus Curr. (C.F.) 10. V.
* hyperboreus Staeg. (C.C.) 12. VIII.
* immarginatus Zett. (C.F.) 10. VII–VIII.
* modestus Ide (C.F.) 10. VI.
nodosus Curr. 19. VI.
* peltatoides Curr. ? (C.F.) 8. VI.
* peltatus Mg. (C.C.) 10, 18. VII–VIII.
* perpallidus Verr. (C.F.) 3, 8, 10. V–VII.
podagratus Fab. 19. V–VII.
* quadratus Say (E.S.) 3. VI.
* scutatus Mg. (C.F.) 10, 19. IV–VI.
* **Melanostoma** angustatum Will (C.C.) 18. VII.
* caerulescens Will. (C.C.) 1, 3, 6. V–VI.
* nr. chaetopoda Dav. (C.F.) 12. VI.
chilosia Curr. 19.
fallax Curr. 19. V.
* monticola Jones (C.F.) 10. V.
* nr. obscurum Say (C.F.) 12. VI.
* pallitarsis Curr. (C.F.) 10, 12. VI–VII.
* pictipes Big. (C.F.) 8, 10. V–VII.
* rufipes Will. (C.C.) 18. VII.

CHEILOSINAE

* **Cartosyrphus** canadensis Shn. (C.C.) 18. VI–VII.
* kincaidi Shn. (C.F.) 10. V–VI.
laevis Big. 19. VII.
luctus Snow 19. VI.
* plutonia Hunt. (C.C.) 10, 18. VII.
* sialia Shn. (C.F.) 10, 12. V–VI.
* tristis Lw. (C.C.) 10, 18, 20. V–VII.
* **Cheilosia** bicolorata Shn. (C.F.) 10. V.
ferruginea Lov. 1. V.
* florella Shn. (C.F.) 8, 10. V–VI.
hesperia Shn. 10. VI.
* lasiophthalma Will. (C.C.) 1, 10. V.
* nigroapicata Curr. (C.C.) 1, 10. V–VI.
nigrovittata Lov. 19. V-VI.
* orilliaensis Curr. (C.F.) 10. VII.
* robusta Hine (C.C.) 6, 18. VI–VII.
* variabilis Panz. (C.C.) 18. VII.
* **Pipizia** femoralis Lw. (C.F.) 10, 12, 20. V–VII.
* macrofemoralis Curr. (C.C.) 18. VII.
* oregona Lov. (C.C.) 10, 18. VI.
* quadrimaculata Panz. (C.C.) 18, 19. VI–VII.
* vanduzeei Curr. ? (C.F.) 8, 10. VI.
* **Cnemodon** auripleura Curr. (C.C.) 3, 6. VI–VII.
* calcarata Lw. ? (C.F.) 10. V.

SYRPHIDAE—*continued.*

Cnemodon nigricornis Curr. 19. VI.
rita Curr. 18. VII.
* **Pipizella** apisaon Wk. (C.F.) 8, 10. VI.
* recedens Wk. (C.F.) 8, 10. VII.
* **Chrysogaster** parva Sch. (C.C.) 3, 8. V–VI.
* pictipennis Lw. (C.F.) 8, 10. V–VI.
* pulchella Will. (C.F.) 8, 10, 20. V–VIII.
* **Neoascia** conica Curr. ? (C.F.) 10, 19. V–VII.
metallica Will. 19. V–VI.
sphaerophoria Curr. 19. V–VI.
* unifasciata Curr. ? (C.F.) 10, 12. VI–VIII.
* **Hammerschmidtia** ferruginea Fall. (C.C.) 18. VII.
* **Rhingia** nasica Say (C.C.) 10, 15, 16, 18. VI–VII.
* **Brachyopa** notata O.S. (C.F.) 10. V.
* vacua O.S. (C.F.) 12. V.

XYLOTINAE

There appears to be some difference of opinion among authorities regarding the generic designation of several species included in this subfamily. We have attempted to follow Curran, but we fail to see how *Eumerus strigatus* can be included in the genus *Heliophilus* where we have placed it, on his authority.

* **Cynorhina** armillata O.S. (C.C.) 18. VII.
* garretti Curr. (C.F.) 8, 19. VIII.
* nigripes Curr. (C.F.) 10. VI.
* **Brachypalpus** (**Xylotodes**) parvus Will. (C.C.) 6, 10. V.
* rileyi Will. (C.C.) 10. IV–V.
* inarmatus Hunt. (C.F.) 10. VI.
* pigra Lov. (C.F.) 12. V.
* **Heliophilus** (**Xylotomima**) curvipes satanica Big. (C.F.) 8, 10. VI–VII.
* nemorum americanum Shn. (C.F.) 10. V.
* vecors O.S. (C.F.) 10. V.
* (**Xylota**) ejuncida Say (C.F.) 12. VII.
* elongata Will. (C.F.) 8. VI.
* flavitibia Big. (C.F.) 8, 19. VI–VIII.
* naknek Hine (C.F.) 8, 10, 16. VI–VIII.
subfasciatus Lw. (C.C.) 8, 10, 18. VI–VII.
(**Eumerus**) strigatus Fall. (C.C.) 3, 10. V–VII.
Rather injurious to onions in drier part of the province. Rare around Edmonton.
* **Spilomyia** quadrifasciata Say. (C.C.) 2, 15. VII–VIII.
* **Temnostoma** apiforme Fab. (E.S.) 10, 15. VI.
* bombylans F. ? (C.F.) 10. V.
* **Tropidia** quadrata Say. (C.F.) 10, 20. VI–VIII.
* **Syritta** pipiens L. (C.C.) 2, 3, 5, 8, 10, 12, 15. V–VIII.

SERICOMYINAE

* **Sericomyia** militaris Wlk. (C.C.) 1, 10, 20. VII–VIII.
Pyritis montigena Hunt 8. IV.
* **Arctophila** flagrans O.S. (C.C.) 6, 18, 19. VII–VIII.

SYRPHIDAE—*concluded.*

ERISTALINAE

* **Eristalis** anthophorinus Fall (= montanus) 1–3, 10, 12. V–VIII.
* bastardi Mg. (J.A.) (? = anthophorinus) 10, 12. VII–VIII.
* brousii Will. (C.F.) 2, 3, 6, 10. V–IX.
* compactus Walk. (C.F.) 19, 20. VII.
* dimidiatus Wd. (C.C.) 10. VIII.
* flavipes Walk. (C.C.) 3, 5. V and IX.
* hirtus Lw. (J.A.) (? = latifrons) 19. VII–VIII.
* latifrons Lw. (C.C.) 3, 4, 6, 10, 19. VIII.
* nemorum L. (C.F.) 15, 19. VI.
occidentalis Will. 19.
* rupium Fab. (C.F.) 10, 12, 20. VI–VII.
* temporalis Thom. (C.C.) 3, 18. VII–VIII.
* tenax L. (C.C.) 1–3, 6, 8, 10, 15, 18. VIII–X.
* campestris Mg. (E.S.) 3. VIII.
Merodon equestris Fab. 10. IV.
Determined from Edmonton material by Curran. We have not seen a specimen and have no records of injury.
* **Polydontomyia** curvipes Wd. (C.C.) 2, 10. V–VIII.
* **Lejops** bilinearis Will. (C.F.) 10. VI.
* perfidiosus Hunt. (C.F.) 10, 19. VI–VII and X.
* stipatus Walk. (E.S.) 2, 10. VI–VII.
* **Parhelophilus** obsoletus Lw. (C.F.) 10. VI.
porcus Walk. 19. VII.
Elophilus borealis Staeg. "Alberta".
* hybridus Lw. (C.C.) 4, 10. V–VIII.
Several adults were taken from under stones around a grain field in May.
* latifrons Lw. (C.C.) 2, 3, 6, 10. V–VIII.
* obscurus Lw. (C.C.) 3, 10, 20. VI–VII.
stricklandi Curr. 10. V.
* **Asemosyrphus** willingi Sm. (C.C.) 3, 10. V–VIII.

CONOPIDAE. Thick-headed flies, bee and wasp parasites

* **Physocephala** affinis Will. (C.C.) 3. VIII.
* buccalis V.D. (F.C.) 3. VIII.
* furcillata Will. (C.C.) 9, 10, 12, 15. VII–VIII.
* marginata Say. (C.C.) 3. VI.
* **Zodion** fulvifrons Say (F.C.) 3, 8. VI–VIII.
obliquefasciata Macq. 2, 3, 10. VI–VIII.
* occidentale Bnks. (C.C.) 3, 18. VI–VIII.
* **Myopa** longipilis Bnks. (C.C.) 6. V.
* seminuda Bnks. (? = rubida) (F.C.) 10. V.
* vesiculosa varians Bnks. (C.C.) 2, 6. V.
* vicaria Wlk. (C.C.) 9, 10. IV–V and VIII.
* **Occemya** baroni Will. (F.C.) 3, 10. V–VII.
* terminalis V.D. (F.C.) 10.

OTITIDAE (ORTALIDAE). Pictured-wing flies

* **Oedopa** capito Lw. (C.C.) 3. VI.
* **Seioptera** colon Lw. (C.C.) 3. VI–VII.
* vibrans L. (C.C.) 3, 8, 10. VI–VIII.
* **Chrysomyza** demandata Fall. (C.C.) 3. III and VII.

OTITIDAE—*concluded.*

Pseudotephritis corticalis Lw. 10. V.
* cribellum Lw. (E.S.) 3. VII.
metzi Joh. 10.
* **Tritoxa** cuneata Lw. (C.C.) 3, 15, 18. VI–VII.
* **Rivellia** flavimana Lw. (C.C.) 2. VII.
* **Melieria** obscuricornis Lw. (C.C.) 2, 3. V–VI.
* ochreicornis Lw. (C.C.) 3, 6, 10. VI–VIII.
* **Tetanops** aldrichi Hend. (C.C.) 2, 3, 5-7, 9, 18. V–VIII.

The sugar-beet root-maggot has become a serious pest in southern Alberta. Damage was first observed in about 1930. Adults have been taken in numbers since 1916.

* **Ceratoxys** (**Anacampta**) pyrocephala Lw. (C.C.) 2. VII.

TRUPANEIDAE (TRYPETIDAE). Fruit flies

* **Epochra** canadensis Lw. (E.S.) 2, 3, 6, 10, 15. V–VII.

The currant fruit fly is found wherever currants and gooseberries grow, wild or cultivated. It is an increasingly serious pest of cultivated varieties.

* **Zonosema** flavinotata Macq. (F.M.) 10. VI and VIII.
* setulosa Doane (E.S.) 10, 18. VII.

Rhagoletis pomonella Walsh (? = symphoricarpi Curr.) 3. VII.

This breeds in *Symphoricarpus* berries in Alberta. As such, it was described as a new species by Curran. Cresson states that it is *pomonella*. We have no records of it attacking apples in Alberta.

* tabellaria Fit. (E.S.) 10, 15. VI–VII.
* **Trypeta** occidentalis Snow (C.C.) 2, 3, 6, 18. VI–VIII.
* **Terellia** palposa Lw. (F.M.) 15. VIII.

Adults taken exclusively from blossoms of "bull-thistle".

* **Straussia** longipennis Wd. (C.C.) 3. VI–VII.

The sunflower maggot is an appreciable pest of sunflowers grown for silage, in southern Alberta.

* longitudinalis Lw. 3. (E.S.) VII.
* vittigera Lw. (E.S.) 8. VI.
* **Tephritis** aequalis Lw. (C.C.) 3. VIII.
* albiceps Lw. (C.C.) 3, 10. VI.
* angustipennis Lw. (F.M.) 10. VII.
aldrichi Hine 18. VI.
* murina Doane (C.C.) 3. VIII.
* pura Lw. (F.M.) 8, 10, 15. V–VII.
* (? = **Euribia**) clathrata Lw. (E.S.) 15.

Stenopa vulnerata Lw. 19.
* **Paracantha** culta Lw. (C.C.) 1, 6. V–VII.

Eutreta diana O.S. 2. VIII.
* longicornis Snow (C.C.) 2. VI–VIII.
* **Eurosta** comma Wd. (C.C.) 2. VIII.
* solidaginis fascipennis Curr. (C.C.) 10. IV.
* subfascipennis Curr. (C.C.) 2. V.

This stem-gall fly of goldenrod is annually very abundant at Edmonton.

PALLOPTERIDAE.

* **Palloptera** albertensis Joh. (C.J.) 6. VII.

LONCHAEIDAE.

* **Lonchaea** laticornis Mg. (E.S.) 18, 19. VII–VIII.
* polita Say. (E.S.) 15. VI.
* ursina Mall. (E.S.) 10. VII.

TANYPEZIDAE.

* **Tanypeza** picticornis C. & S. ? (G.S.) 10. VI–VII.

CALOBATIDAE. Stilt-legged flies

* **Calobata** mima Cress. (C.C.) 7, 10. VI.
* univittata Walk. (E.S.) 10. VII.

MICROPEZIDAE.

Micropeza lineata V.D. 2.
* turcata Twns. 2, 3. (C.C.) VI.

PIOPHILIDAE. Cheese skippers

* **Piophila** affinis Mg. (C.C.) 18. VI.
casei L. (?).
A sample of oats, submitted for a germination test, was heavily infested with "cheese skippers". Correspondence elicited the fact that these oats had been kept in a room where cheese was being made.

SEPSIDAE. Small scavenger flies

* **Nemopoda** cylindrica Fab. (E.S.) 10. VII–VIII.
* **Sepsis** pectoralis Macq. (C.C.) 3, 9, 10. VII.
* signifera Mel. (C.C.) 2, 15. VI.
* vicaria Walk. (E.S.) 10, 15. V–VI.
* violacea Mg. (C.C.) 3, 9, 19. VI.
* similis Macq. (C.C.) 19. IV–VI.
* **Themira** putris L. (E.S.) 2, 10. VII–VIII.

LAUXANIIDAE, (SAPROMYZIDAE).

* **Lauxania** cylindricornis Fall. (C.C.) 2, 3, 10. V–VII.
* **Camptoprosopella** vulgaris Fitch (G.S.) 2, 3, 10. VI–IX.
Adults can be swept from potatoes, in large numbers, any time during the summer.
* **Minettia** americana Mall. (G.S.) 10. V–VI.
* americanella Shew. (G.S.) 10. V–VI.
flaveola Coq. 3. VI.
* lupilina Fab. (C.C.) 3, 15, 18. VI–VII.
* **Homoneura** bispina Lw. (G.S.) 3. VII.
* lyraformis Shew. (G.S.) 10. VI.
* seticauda Mall. (C.C.) 3. VII.
* **Sapromyza** cyclops Mel. (C.C.) 3. VI–VIII.
fusca Shew. (G.S.) 10.
* hyalinata Mg. (G.S.) 10. V–VIII.
monticola Mel. (G.S.) 18. VII, IX.
* ouelleti Shew. (G.S.) 10, 12. V–VIII.

DROSOPHILIDAE. Pomace flies

* **Drosophila** buscki Coq. (C.C.) 3, 10. II and X.
* funebris Fab. (G.S.) 10, 15. IV–VI.

ASTEIIDAE.

* **Asteia** nr. beata Ald. (F.M.) 10. VI.
Shewell states that this species is undescribed.

AGROMYZIDAE.

* **Cerodontha** dorsalis Lw. (C.C.) 2. VI.
* **Agromyza** angulata Lw. (G.S.) 10, 20. VII.
* artemisiae Kalt. (C.C.) 2. V.
* laterella Zett. (G.S.) 10. VIII.
* neptsi Lw. (G.S.) 10. VI.

PHYLLOMYZIDAE.

* **Hypaspistomyia** halteralis coq. (G.S.) 3. V– VII.
* **Phloeleomyia** indecora Lw. (C.C.) 2, 3. V–VI.

CHLOROPIDAE, (OSCINIDAE). Frit flies and stem maggots

* **Meromyza** americana Fit. (C.S.) 3, 18. VI–VII.
Adults common in southern Alberta. No records of damage to wheat.
* lineola Curr. (E.S.) 15.
marginata Beck. 15. VIII.
* **Chloropisca** glabra Mg. (C.S.) 3, 5, 8, 10. V–VII.
Puparia taken in very large numbers from wheat stubble at Drumheller. Predator on root aphids.
* grata Lw. (C.S.) 3, 8. VII.
* pulla Lw. (C.S.) 3, 8. V–VI.
* variceps Lw. (C.S.) 8, 10, 12. IV–V and VIII–IX.
Adults swarm on outside walls and windows. Often enter houses. Most abundant in autumn.
* **Epichlorops** exilis Coq. (C.S.) 10. VII.
This large species is taken freely in slough grass.
Chlorops ingrata Curr. 3.
* producta Lw. (C.C.) 2. VI.
* sulphurea Lw. (C.C.) 2. VI.
Gaurax festivus Lw. 3. VII.
Bred from a circular leaf mine in cottonwood poplar at Lethbridge.
Madiza cinerea Lw. 3, 5. V–VII.
* oscinina Fall. (C.S.) 15. VI.
parva Adam. "Alberta".
* **Oscinella** coxendix Fit. (C.S.) 2, 3. VI.
* pullicornis Sab. (C.S.) 3, 10. V–VII.
* frit L. (C.S.) 3, 8. VI.
Not common. No damage to grain noted.

EPHYDRIDAE. Brine flies

Psilopa compta Mg. 3. V.
* **Ochthera** mantis deG. (E.S.) 2, 10. IV–VI and X.
* **Parydra** bituberculata Lw. (C.C.) 2, 10. VI and IX.
* **Notiphila** scalaris Lw. (C.C.) 3, 10. VI.
Philygra fuscicornis Lw. 3. V–VI.
This record from Canadian Entomological Record, 1916. The genus is not included in Curran's Diptera of North America.

BORBORIDAE. Small dung flies

* **Sphaerocera** subsultans Fab. (C.C.) 5, 10, 15, 18. V–VII.
Larvae and adults very abundant in soil of well-manured seed bed of cabbages at Edmonton. No damage.
* **Leptocera** atra Adam. (C.C.) 3, 10. VI–VIII.
* fontinalis Fall. (C.C.) 2, 3. IV–VI.
* limosa Fall. (C.C.) 2, 10, 20. IV–VII.
* lutosa Stn. (C.C.) 2, 10, 20. VI–VII.
* **Borborus** equinus Fall. (C.C.) 3, 10, 20. V–VII.
Adults very common, frequently almost cover fresh horse droppings.

CLUSIIDAE.

* **Clusiodes** melanostoma Lw. (E.S.) 10, 15. VI.

CHAMAEMYIDAE.

* **Leucopsis** americana Mall. (E.S.) 10. IX.
Swept from potatoes heavily infested with Psyllids and a few aphids, at Edmonton. Larvae recorded as predators on aphids.
* **Plunomia** elegans Hall. (G.S.) 10. VI.

TETANOCERIDAE (SCIOMYZIDAE). Marsh flies

* **Sciomyza** simplex Fall. (E.S.) 8, 10. VI–VII.
Pteromicra canadensis Curr. 19. V.
* **Melina** albocostata Fall. (C.C.) 2. VI.
* nana Fall. (E.S.) 10. VI–VIII.
* obtusa Fall. (C.C.) 3. VIII.
* schoenherri Fall. (E.S.) 10. VII.
* vitalis similis Cress. (E.S.) 10. VIII.
* **Sepedon** armipes Lw. (E.S.) 8, 10. VI and IX.
* fuscipennis Lw. (C.C.) 3. VIII.
* pacifica Cress. (E.S.) 3. VIII.
* pusillus Lw. (E.S.) 10, 12, 15. VI and IX.
* **Dictya** umbroides Curr. (E.S.) 9, 19, 20. VII.
* **Hedroneura** lineata (? = rufa) (E.S.) 10, 15. VI–VIII.
* **Tetanocera** papillifera Mel. (C.C.) 2. VIII.
* phyllophora Mel. (E.S.) 20. VII.
* plebeia Lw. (C.C.) 20. VII.
* rotundicornis Lw. (E.S.) 10. VI.
* silvatica Mg. (E.S.) 8. VI.
* triangularis Lw. (C.C.) 3, 10. VIII.
* valida Lw. (E.S.) 7. 10. VI.
* vicina Macq. (C.C.) 3, 10, 20. VI–VIII.
* **Limnia** saratogensis Fit. (E.S.) 8, 9. VI.
* ottawensis Mel. (E.S.) 10. VII.

CHYROMYIDAE.

* **Trixoscelis** fumipennis Hall. (G.S.) 10, 12. VI.

PSILIDAE.

* **Pseudopsila** perpolita Joh. ? (G.S.) 12. IX.
* **Psila** atrata Mel. ? (F.M.) 15. VI.

HELOMYZIDAE.

* **Suilla** nemorum Mg. (C.C.) 10, 15. VI–VII.
* **Pseudoleria** vulgaris Garr. (E.S.) 3. VI.

HELOMYZIDAE—*concluded.*

"Leria"? pectinata Lw. "Alberta".
* **Helomyza** serrata L. (C.C.) 2, 3. V and VII.
* **Tephrochlamys** canescens Mg. (C.C.) 15, 18. V–VI.
* **Eccoptomera** americana Darl. (E.S.) 8. VI.
* **Anorostoma** marginata Lw. (F.M.) 15. VII.
* **Acantholeria** oediemus Garr. (C.C.) 10. VII–VIII.
Barbastoma barbatus Garr. 19.
Recorded by Garrett, Ins. Ins. Mens. 1924. Genus not included in Curran.

MUSCIDAE. Dung flies, House flies, Root maggots, etc.

CORDYLURINAE or SCATOPHAGINAE Dung flies

Allomyella robusta Curr. 19. VII.
* **Scatophaga** (? = **Scopeuma**) furcata Say. (C.C.) 2, 19. V.
* merdaria Fab. (C.J.) 6. VIII.
Adults recorded as feeding on leaf-hoppers. (Childs.)
palpalis Mall. 19.
* stercoraria L. (F.S.) 2, 3, 6, 8, 10, 20. V–VII.
* suilla Fall. (F.S.) 10, 20. V–VII.
* **Acicephala** intermedia Curr. (C.C.) 1. VI.
alberta Curr. 19. V–VII.
* **Cordilura** alberta Curr. (F.S.) 8, 19. VI–IX.
* beringensis Mall. (F.S.) 8. VI.
* browni Curr. (F.S.) 8. VI.
* confusa Lw. (F.S.) 8, 10, 12. V–VII.
Adults swarm among rushes by water.
* fasciventris fulvithorax Curr. (C.C.) 8, 19. VI–VIII.
* latifrons Lw. (F.S.) 8, 12. VI.
* masconina Curr. (F.S.) 8. VI.
varicornis Curr. 19. V–VII.
* **Spaziphora** cincta Lw. (F.S.) 8. VI.
Adults abundant among rushes by water.
* **Pogonota** fulvibarbra Lw. (F.S.) 10. VII.
Trichopalpus nigribasis Curr. 19. VII–VIII.
* **Achaetella** varipes Wlk. (F.S.) 5, 8, 10. VI–VIII.
* **Parallelomma** pleuritica Lw. (F.S.) 8, 20. VI–VII.
Adults common on foliage near water.
* **Chaetosa** punctipes Mg. (F.S.) 8, 10. VI–VIII.
* **Hexamitocera** vittata Coq. (F.S.) 10. VI.
* **Orthacheta** brunneipennis Joh. (F.S.) 8, 12, 19. VI–VII.
* hirtipes Joh. (F.S.) 10. VIII.
Amaurosoma alberta Curr. 18. VI.

MUSCINAE House fly sub-family

We have removed these from the Anthomyinae, with which they are interspersed in Curran's key.

* **Musca** domestica L. (H.H,) 1–10, 12, 14, 18–21. I–XII.
* **Orthellia** (= **Cryptolucilia**) caesarion Mg. (R.S.) 1–3, 10. IV–VIII.
* **Pyrellia** cyanicolor Zett. (? = serena) (R.S.) 10. V–VI.
* **Morellia** micans Macq. (R.S.) 3, 10. VI–VIII.
* **Hypodermodes** solitaria Knab (J.A.) 6, 10. VI.
* **Mesembrina** latrielle R-D. (H.H.) 10. VII.
* **Graphomyia** maculata Scop. (R.S.) 8, 10, 20. VI–VII.

MUSCIDAE—*continued.*

MUSCINAE—*concluded.*

* **Muscina** assimilis Fall. (R.S.) 10, 19. III–V and VIII–IX.
Larvae recorded as mining in roots.

* stabulans Fall. (H.H.) 3, 6, 10. V–VIII.
Larvae found in decaying vegetation, as parasitoids of other insects, and in human alimentary canal.

Stomoxys calcitrans L. 19.
Recorded from Banff, but has not been found anywhere further north.

* **Haematobia (Lyperosia)** irritans L. (H.H.) 10. VIII.
Appears to be rare in Alberta. No reports of attacks on cattle have been received.

ANTHOMYINAE S.L. Root maggots, Leaf miners, etc.

Species belonging to this sub-family have been collected intensively in the southern portion of the province by Mr. H. L. Seamans. During the past three years we have made large collections in the northern part of Alberta. All collections have been determined by Dr. H. C. Huckett. Since nearly 30% of the species captured in 1937 were new records for the province, it is probable that the fauna in this sub-family is still very imperfectly known.

* **Eremomyoides** cylindrica Stn. (H.H.) 10, 12. V.
* parkeri Mall. (= setosa)(H.H.) 3, 10. IV–V.
Hydrophoria bispinosa Zett. 12. VII.
* brunneifrons Zett. (H.H.) 3, 10. V–VII.
* divisa Meig. (H.H.) 3, 10, 19. V–VIII.
* flavohalterata Mall. (H.H.) 10. VI.
occulta Meig. 12. VII.
* ruralis Meig. (H.H.) 19. IX.
* subpellucens Mall. (H.H.) 8. VI.
* wierzejekii Mik. (H.H.) 10. VI–VIII.
* zetterstedti Ring. (H.H.) 8, 10, 18. V–VII.
* **Calythea** micropteryx Thom. (H.H.) 10. X.
* separata Mall. (H.H.) 3. VIII.
* **Anthomyella** pratincola Panz. (H.H.) 3, 4, 10. V–VIII.
* **Pegomya** apicalis Stn. (H.H.) 18. VII.
* connexa Stn. (H.H.) 10. VIII.
* duplicata Mall. (H.H.) 10. VII.
* flavicans Stn. (F.S.) 10. VII.
* geniculata Bouch. (H.H.) 8, 10. VI–VIII.
* hyoscyami Panz. (H.H.) 3. VIII.
Though the "beet and spinach leaf-miner" has been taken in southern Alberta it does not appear to be of any economic importance here.
* incisiva Stn. (H.H.) 3. VI.
* lipsia Walk. (H.H.) 10. VIII–IX.
* luteola Mall. (H.H.) 10. VII.
* nigroscutellata Stn. (H.H.) 10. V and VIII.
* quadrispinosa Mall. (H.H.) 18. VII.
unguiculata Mall. 19. VII.
* vittigera Zett. (H.H.) 10. VIII.
* **Hammomyia** personata Coll. (H.H.) 10. IV–V.
* unilineata Zett. (H.H.) 10. IV–V.
* unistriata Zett. (H.H.) 10. V.

MUSCIDAE—*continued.*

ANTHOMYINAE—*continued.*

* **Egle** bicaudata Mall. (H.H.) 10. IV–V.
* fuscohalterata Mall. (H.H.) 10. IV–V.
* longipalpis Mall. (H.H.) 10. V.
* muscaria Fab. (H.H.) 10. IV–V.
* salicola Huck. (H.H.) IV–V.
All species in this genus, which we have seen, visit salix blossoms in April and May, but have never been seen later in the year.
* **Paregle** cinerella Fall. (H.H.) 1–3, 6, 10, 18, 20. VI–VIII.
* radicum L. (H.H.) 3, 10, 15. V–X.
* **Prosalpia** angustitarsis Mall. (H.H.) 10. VI.
* longipennis Ring. (H.H.) 10. V.
* silvestris Zett. (H.H.) 10. VI–VIII.
* **Eremomyia** incompleta Stn. (H.H.) 2. III.
* **Hylemyia** angusta Stn. (H.H.) 1, 8, 10, 18. VI–VII.
* antiqua Mg. (H.H.) 2, 3, 10, 15. IV–VIII.
The onion maggot is widespread in the province.
aquitima Huck. 18. VI–VII.
* betarum Lint. (H.H.) 10. IX.
Larvae mine in beet leaves. Of no economic importance in Alberta.
* brassicae Bouch. (H.H.) 3, 10, 15. V–VII.
The cabbage root-maggot is a serious pest in Alberta.
brevipalpis Huck. 18. VII.
brunetta Huck. 19. VII.
* canadensis Huck. (H.H.) 10, 19. V–VI.
Adults sometimes very abundant in brome grass. No larvae found.
* cerealis Gill. (H.H.) 1, 3. VI–VIII.
Larvae infest wheat in Montana. All larvae bred from this crop in Alberta have belonged to other species.
* cilicrura Zett. (H.H.) 1–4, 8, 10, 20. V–VIII.
Adults very abundant and widespread throughout province. No records of injury to wheat or corn have been received, though they are reported from Saskatchewan.
* coenosiaeformis Stn. (H.H.) 3, 10, 12, 20. V–VIII.
* collini Ring. (H.H.) 10. VI.
cruciferae Huck. 3, 19. VI–VIII.
* depressa Stn. (H.H.) 3, 10. VI–VIII.
equifrons Huck. 19. VII.
* extremitata Mall. (H.H.) 10. VII.
* floralis Fall. (H.H.) 3, 10. VI–VII.
In 1929 this fly destroyed large areas of stinkweed (*T. arvense*) in the Peace River District. The larvae inhabited the crowns of the plants which, in many instances, were entirely severed from the roots.
frontulenta Huck. 3. V.
garretti Huck. 20. VII.
gemina Huck. 19. V–VI.
* hinei Mall. (H.H.) 10. IV–VII.
* impersonata Huck. (H.H.) 10. VI.
* inornata Stn. (H.H.) 15. VI.
* lasciva Zett. (H.H.) 8, 10. V–VII.
* latipennis Zett. (H.H.) 10. V–VI.
* linearis Stn. (H.H.) 10. IV–VI.
* lineariventris Zett. (H.H.) (= uniseriata) 8, 10, 18, 19. V–VIII.

MUSCIDAE—*continued.*

ANTHOMYINAE—*continued.*

Hylemyia lobata Huck. 19. V.
marginata Stn. 19. VII.
* montana Mall. (H.H.) 3. VII–VIII.
mutans Huck. 3. V.
* neomexicana Mall. (H.H.) 3, 6, 8, 10, 19, 20. VI–IX.
The larvae of this species, which have a black stigmal plate, have been bred from wheat seedlings at Granum.
nigricaudata Huck. 18. VII.
* normalis Mall. (H.H.) 3, 6. VI–VII.
Larvae bred from wheat seedlings at Granum.
* occidentalis Mall. (H.H.) 6, 10. V–VI.
pedicillaris Huck. 19. V.
* penicillaris Stn. (H.H.) 10. V.
pentaformis Huck. 18, 19, 20. VI–IX.
* pilifemur Ring. (H.H.) 10. V–VI.
* planipalpis Stn. (H.H.) 10, 19. V.
* pluvialis Mall. (H.H.) 3, 8, 10, 12, 19, 20. VI–VIII.
propinquina Huck. 18, 19. VII–IX.
* pullula Zett. (H.H.) 10. V.
repleta Huck. 19, 20. IV–VI.
* replicata Huck. (H.H.) 10, 20. V–VIII.
seamansi Huck. 18. VI.
* sepia Meig. (C.C.) 1. VI.
* setifer Mall. (H.H.) 10, 15, 20. VI–IX.
* setigera Joh. (H.H.) 1. VII.
* spiniventris Coq. (H.H.) 20. VII.
* tarsata Ring. (H.H.) 10, 15. V.
* testacea Stn. (H.H.) 3. VII–VIII.
* trilineata Stn. (H.H.) 20. VII.
* variata Fall. (H.H.) 10, 12. VI.
* **Lispe** antennata Ald. (H.H.) 10. VIII–IX.
* palposa Wlk. (H.H.) 12, 20. VII–VIII.
* polita Coq. (H.H.) 3. VI.
* salina Ald. (H.H.) 2, 10. II, V and VIII.
* tentaculata deG. (H.H.) 10. VIII.
* uliginosa Fall. (H.H.) 3, 10, 12, 19. VI–VIII.
* **Pseudophaonia** orichalcea Stn. (H.H.) 10, 20. V–VIII.
Hoplogaster flavidipalpis Huck. 19. VI.
* gilva Zett. (H.H.) 10. VI–VII.
* mollicula Fall. (H.H.) 12, 18, 20. VII–VIII.
octopuncta Zett. 19. VII.
* **Schoenomyza** chrysostoma Lw. (C.C.) 1, 10. V–VI.
* dorsalis Lw. (H.H.) 2, 3, 8, 10, 19. V–VIII.
partita Mall. 19. VI.
* sulfuriceps Mall. (H.H.) 10, 19. VI and IX.
* litorella Fall. (H.H.) 3, 20. VII–VIII.
* **Coenosia** aliena Mall. (H.H.) 18. VI.
alticola Mall. 3. VI.
* argenticeps Mall. (H.H.) 3, 10. VI.
* compressa conforma Huck. (H.H.) 10, 20. VII–VIII.
* incisurata V.d.W. (H.H.) 10. VI.
lata Walk. 1. V.

MUSCIDAE—*continued.*

ANTHOMYINAE—*continued.*

* **Coenosia** nigrescens Stn. (H.H.) 12. VI.
* pallipes Stn. (H.H.) 3, 10, 19, 20. VI–VIII.
* **Limosia** anthracina Mall. (H.H.) 18–20. VII.
* cilicauda Mall. (H.H.) 2, 3, 8, 10, 18. V–IX.
* johnsoni Mall. (H.H.) 10, 18, 19, 21. VII–VIII.
nigricoxa Stn. 19. VI.
* pedella Fall. (H.H.) 8, 10, 19. VI–VII.
pygmaea Zett. 19. VI.
* triseta Stn. (H.H.) 3, 20. VI–VII.
Pseudocoenosia brevicauda Huck. 21. VII.
longicauda Zett. 19. VI–IX.
* **Lispocephala** alma Meig. (H.H.) 10. V.
pallipalpis Zett. 3, 10. IV–VII.
* erythrocera Desv. (H.H.) 2, 3, 10, 20. V–X.
* rubicornis Zett. (F.S.) 20. VII.
* **Macrorchis** alone Walk. (H.H.) 10. V.
* **Limnospila** albifrons Zett. (H.H.) 10. VI–VIII.
* **Azelia** gibbera Meig. (H.H.) 20. VII.
* triquetra Zett. (H.H.) 20. VII.
* **Fannia** canicularis L. (H.H.) 3, 10, 19. V–IX.
* carbonaria Meig. (H.H.) 10. VI.
* genualis Stn. (H.H.) 10. VIII.
* glaucescens Zett. (H.H.) 3. V–VII.
* immaculata Mall. (H.H.) 10. VI.
* incisurata Zett. (H.H.) 3. VI.
* laevis Stn. (H.H.) 10. VI.
* manicata Meig. (H.H.) 10. VIII.
* pallidiventris Mall. (H.H.) 12. VII.
* postica Stn. (H.H.) 10. VI.
* scalaris Fab. (H.H.) 3, 10, 15, 19. V–IX.
* serena Meig. (H.H.) 10. VI.
* sociella Zett. (H.H.) 10. V.
* spathiophora Mall. (H.H.) 10. VII.
tibialis Mall. 3, 18. V–VII.
* **Limnophora** discreta Stn. (H.H.) 10, 19, 20. VI–VII.
narona Walk. 20. VIII.
(**Pseudolimnophora**) nigripes R-D. 20. VII.
(**Lispoides**) aequifrons Stn. 6. IX.
(**Sphenomyia**) biquadrata Walk. 19.
(**Spilogona**) alberta Huck. 19. VI–VII.
alliterata Huck. 19. VII.
alticola Mall. 19. VI.
anthrax Big. 18, 19. VII.
* argentiventris Mall. (H.H.) 3. VI.
occidentalis Huck. 19. VIII.
brevicornis Mall. 3. VI.
* concolor Stn. (H.H.) 10, 19–21. VII–VIII.
cretans Huck. 3. V–VI.
fimbriata Huck. 18. VII.
* fumipennis Zett. (H.H.) 10. VI.
fuscomarginata Huck. 19. VII.
* gibsoni Mall. (H.H.) 10, 18. VI–VII.

MUSCIDAE—*continued.*

ANTHOMYINAE—*continued.*

Limnophora imitatrix Mall. 19. VI–VII.
* leucogaster Zett. (H.H.) 10. V–VIII.
magnipunctata Mall. 18. VI–VIII.
* narina Walk. (H.H.) 10. VII.
rufitarsis Stn. 18, 21. VII–VIII.
sectata Huck. 19. VII.
subrostrata Stn. 19. VII.
surda Zett. 19, 20. VI–VII.
* suspecta Mall. (H.H.) 10. VI.
* tetrachaeta Mall. (H.H.) 3. VI–VIII.
* trigonifera Zett. (H.H.) 10. VII–VIII.
* **Myospila** meditibunda Fab. (H.H.) 3, 10, 18. V–VIII.
* **Mydaea** brevipilosa Mall. (H.H.) 10. VI.
* discimana Mall. (H.H.) 10, 20. V–VII.
* occidentalis Mall (H.H.) 10. VI–VIII.
* persimilis Mall. (H.H.) 10, 19. VI.
punctata Stn. 3. VI.
* **Lasiops** conformis Mall. (H.H.) 19, 20. VII.
* innocuus Zett. (H.H.) 10, 19, 20. VI–VII.
* johnsoni Mall. (H.H.) 10, 12. VI.
* latipennis Mall. (H.H.) 10. VII.
* melanderi Mall. (H.H.) 10. V–VI.
* septentrionalis Stn. (H.H.) 15, 18–20. VII–IX.
* spiniger Stn. (H.H.) 10, 20. VI–VII.
* **Alloestylus** diaphanus Wied. (H.H.) 10. VI and IX.
* **Bigotomyia** houghi Stn. (H.H.) 10. VII.
* **Dendrophaonia** querceti Bouch. (H.H.) 10. VIII.
* **Ophyra** leucostoma Weid. (H.H.) 3, 8, 10, 18. VII–VIII.
* **Spilaria** lucorum Fall. (H.H.) 8, 10, 18. VI–VIII.
* marmorata Zett. (H.H.) 10, 20. VI–VII.
* punctata Stn. (H.H.) 2, 3, 10, 18. V–VII.
Several bred from puparia taken from soil under red currant bushes, at Edmonton.
* **Helina** barpana V.d.W. (H.H.) 10, 15. VI–IX.
* brevis Mall. (H.H.) 1, 3, 10, 20. VI–VIII.
* duplicata Mg. (H.H.) 1–3, 6, 10, 20. V–VIII.
* flavocalyptrata Stn. (H.H.) 10, 18, 20. VI–VII.
* fulvisquama Zett. (H.H.) 18. VII.
* latifrontata Mall. (H.H.) 10, 19. VII–VIII.
* marmorata Zett. (H.H.) 10. VI–VIII.
* multiseriata Mall. (H.H.) 3. VII–VIII.
* neopoeciloptera Mall. (H.H.) 10. IV–V.
* nigricans Mall. (H.H.) 6, 10, 20. V–VIII.
* nigripennis Walk. (H.H.) 8, 10. VI–VIII.
* nigrita Mall. (H.H.) 10. VII.
* nitida Stn. (H.H.) 10. VIII.
* obscurata Mg. (H.H.) (= nasoni) 10. VI–VIII
* pectinata Joh. (H.H.) 10. VI.
* procedens Walk. (H.H.) 10. VII.
* rufitibia Stn. (H.H.) 10. VI.
tuberculata Mall. 19. VII.

MUSCIDAE—*concluded.*

ANTHOMYINAE—*concluded.*

* **Phaonia** apicata Joh. (H.H.) 8, 10. VI.
* basiseta Mall. (H.H.) 3, 6, 8, 10, 18. V–VI.
* brunneinervis Stn. (H.H.) 10, 18. VI–VII.
* bysia Walk. (H.H.) 10. VII–VIII.
* caerulescens Stn. (H.H.) 10. V.
* consobrina Zett. (H.H.) 10. V.
* errans Mg. (H.H.) 10. VIII.
* frenata Holm. (H.H.) 10. IX.
harti Mall. 8.
* monticolor Mall. (H.H.) 18–20. VII.
* nigricans Joh. (H.H.) 10. V.
pallida Stn. 18. VII.
* protuberans Mall. (H.H.) 19. VIII.
* rufibasis Mall (H.H.) 3. VII.
* serva Meig. (H.H.) 10, 12. VI–VIII.
* soccata Walk. (H.H.) 10. VI.
* solitaria Stn. (H.H.) 10. VI.
trivialis Mall. 19.
* **Hydrotaea** acuta Stn. (H.H.) 3. VI.
* armipes Fall. (H.H.) 3, 10. V–VII.
* cristata Mall. (H.H.) 12, 18. VI–VII.
* dentipes Fab. (H.H.) 15. VI.
* houghi Mall. (H.H.) 18, 20. VI–VII.
* meteorica L. (H.H.) 3, 7, 8, 10, 18, 20. VI–VIII.
The adults are the most persistent feeders on perspiration, in Alberta. Most abundant in shady places.
* militaris Meig. (H.H.) 10. VII–IX.
* occulta Meig. (H.H.) 10. VIII.
* palaestrica Meig. (H.H.) 10. V.
* scamba Zett. (H.H.) 10, 12, 20. VI–VIII.
* unispinosa Stn. (H.H.) 19, 20. VII.
* **Hebecnema** affinis Mall. (H.H.) 10. VI.
* vespertina Fall. (H.H.) 10, 12. VI–VIII.
* **Phyllogaster** littoralis Mall. (H.H.) 2, 3, 8. VII–IX.
unicus Stn. 3. IX.
Pogonomyia aldrichi Mall. 19. VII.
errans Meig. 18. VII.
latifrons Mall. 18. VI.
* minor Mall. (H.H.) 1, 18. VI.
* nitens Stn. (H.H.) 10, 18, 20. VI–VIII.
* similis Mall (H.H.) 10, 18–20. VI–VII.

GASTEROPHILIDAE. Bot flies of horses

* **Gasterophilus** intestinalis deG. 2, 3, 10. VII–IX.
haemorrhoidalis L. "Alberta".
* veterinus Clk. 3, 6, 10. IX.

METOPIIDAE Flesh flies and blow flies

* **Taxigramma** heteroneura Mg. (C.C.) 2. VII.
Hilarella fulvicornis Coq. 3. VII.
* **Metopia** leucocephala Rossi. (C.C.) 2, 10. VI–VII.
Taken in numbers, on sandy bank inhabited by various bees and wasps.

METOPIIDAE—*concluded.*

* **Wohlfahrtia** meigenii Sch. (F.M.) 3, 10. VIII.
Bred from foot of tame rat. Adults on goldenrod and sweet clover.
Senotainia trilineata V. deW. 3. VII.
* **Cynomya** cadaverina R.D. (R.S.) 2, 3, 6, 10. IV–IX.
Calliphora elongata Hgh. 3. VII.
erythrocephala Meig. 3. X.
* latifrons Hgh. (R.S.) 3. VI.
montana Shn. 10. VIII.
* vomitoria L. (R.S.) 3. 6, 10, 18. V–X.
* **Phormia** regina Mg. (R.S.) 2, 3, 6, 10. II–VIII.
* terra-novae R.D. (R.S.) 2, 3, 6, 10. II–V.
* **Lucilia** caesar L. (R.S.) 2, 10. V–VI.
* serricata Mg. (R.S.) 3. V–VIII.
* sylvarum Mg. (R.S.) 3, 10. VII–VIII.
* **Pollenia** rudis Fall. (F.M.) 10. III–X.
This earthworm parasite was first taken in Alberta at Edmonton in 1935. Was very abundant in 1936 and 1937.
* **Sarcophaga** aculeata Ald. (C.C.) 1. VII.
* aldrichi Park. (F.M.) 10. VI.
Recorded as parasite of tent caterpillar, (Caesar).
* allantis Ald. (F.M.) 4. VI.
* bisetosa Park. (F.M.) 10. VI.
canadensis Hall. 19. VI.
* cimbicis Twns. (F.M.) 8, 10. VI–VII.
* cooleyi Park. (C.C.) 3, 10. VIII.
* falciformis Ald. (F.M.) 3, 20. VII–VIII.
Grasshopper parasite.
* harpax Pand. (C.C.) 18. VII.
* hunteri Hgh. (E.S.) 3. VII.
Grasshopper parasite.
* kellyi Ald. (F.M.) 3. VI.
Grasshopper parasite.
* latisterna Park. (F.M.) 10. VII–VIII.
Recorded as cabbage butterfly parasite.
* l'herminieri R.D. (E.S.) 1, 3, 10, 18. VI–VIII.
* opifera Coq. (E.S.) 3. VI.
* pachyprocta Park. (F.M.) 7 sandy. VI.
* peniculata Park. (F.M.) 10, 20. VI–VII.
* scoparia Pand. (C.C.) 10. VII–VIII.
* sinuata Meig. (F.M.) 10. VII.
Recorded as grasshopper parasite.
* **Agria** affinis Fall. (F.M.) 10. VII.
Recorded as parasite of *V. antiopa.* (Anderson).

CUTEREBRIDAE. Robust bot flies

* **Cuterebra** grisea Coq. (C.C.) 10, 17. VI–VII.
Several bots in mice have been forwarded to us for determination, but all have been dead on arrival.

OESTRIDAE. Bot flies of sheep and cattle

Oestrus ovis L. 4, 10. VI.
Larvae have been taken in numbers from heads of sheep raised near Edmonton.
* **Hypoderma** bovis L. (Hadwen) 3, 8. VII.

TACHINIDAE. Parasitoid flies

* **Hystricia** abrupta Wied. (C.C.) 10, 18. VII–VIII.
Cylindromyia compressa Ald. 19.
* dosiades Walk. (C.C.) 8, 10, 19. VI–VIII.
euchenor Walk. 2. VII.
* intermedia Meig. (C.C.) 3, 10, 18. VI–VIII.
* **Epalpus** signifera Walk. (C.C.) 8, 10. IV–V.
Archytas lateralis Mcq. 2. VIII.
* **Cnephaliodes** algens Wd. (C.C.) 6, 8, 10, 18. VII.
ampliforceps Row. 6, 8. VI–VII.
* argentea Row. (C.C.) 15, 19, 20. VII–IX.
canadensis Toth. 18, 20. VII.
* emarginata Toth. (C.C.) 10. VI.
* hispida Toth. 10, 18. VI–VIII.
* latianulum Toth. (C.C.) 10, 15. VII–VIII.
latiforceps Toth. 19. VI.
* latifrons Toth. (C.C.) 1, 3, 10. VII–VIII.
* piceifrons Tns. (C.C.) 3, 6, 8, 10. V and VIII–IX.
* pilosa Toth. (C.C.) 6, 10, 19. VII–IX.
* rostrata Toth. (C.C.) 3, 10, 15, 19. VII–IX.
* **Belvosia** bifasciata Fab. (C.C.) 6. VII.
canadensis Curr. 6. IX.
* **Parademoticus** piperi Coq. (C.C.) 10. VIII.
Arctophyto marginalis Toth. 19. VII–VIII.
* wickmani Tns. (C.C.) 18, 19. VII–VIII.
* **Cyrtophloeba** horrida Coq. (C.C.) 18. V.
Gymnophania montana Coq. 3. V.
* **Eulasiana** comstocki Tns. (C.C.) 10. VI.
* **Myophasia** clistoides Tns. (C.C.) 10. VII.
* **Polidaria** aeros Walk. (C.C.) 10. VIII.
* **Linnaemyia** compta Fall. (C.C.) 3. V–VI and VIII.
An important parasite of cutworms in southern Alberta.
* haemorrhoidalis Fab. (C.C.) 8, 10. VI–VIII.
* **Lypha** dubia Fall. ? (F.M.) 10. IV.
* **Mericia** ampelus Walk. (C.C.) 10. VIII.
Recorded as parasite of fall webworm. (Tothill).
* arcuata Toth. (C.C.) 10. VI.
Recorded as parasite of fall webworm. (Tothill).
* flavicornis Br. (C.C.) 10. VI.
* nigripalpis Toth. (C.C.) 4, 10. VI and VIII.
* sulcocarina Toth. (C.C.) 10, 20. VI–VII.
* **Rhynchodexia** confusa West. (C.C.) 8, 10. VII–VIII.
* **Imitomyia** sugens Lw. (C.C.) 10. VIII.
* **Melanophrys** insolita Walk. (C.C.) 3. VI.
* **Xanthomelana** arcuata Say (C.C.) 2. VI.
* **Besseria** brevipennis Lw. (C.C.) 2, 3. V–VI.
* **Gymnosoma** fuliginosa Des. (C.C.) 2, 3, 18. VI–VII.
Recorded as a parasite of the wheat bug. (Knowlton).
* occidentale Curr. (C.C.) 10. V and VIII.
Phasia occidentalis Walk. 3, 18. VII.
* **Alophora** aenoventris Will. (C.C.) 12. VIII.
* fenestralis Big. (C.C.) 12. VIII.
* nitida Coq. (C.C.) 12. VIII.
* semiciherea Mg. (C.C.) 2, 3, 10. VI–VII and IX.

TACHINIDAE—*continued.*

* (**Hyalomya**) occidentis Wlk. 2, 6. V and VIII.
* **Voria** americana V.d.W. (C.C.) 10. VI–VII.
rigidirostris V.d.W. 3. VIII.
* ruralis Mg. (C.C.) 10. VII–VIII.
* (? = **Blepharigena**) spinulosa Big. (C.C.) 10, 18. VI–VII.
* **Cryptomeigenia** dubia Curr. ? (F.M.) 10. V–VII.
* triangularis Curr. (F.M.) 10. V–VI.
* **Steveniopsis** sinuata Tns. (C.C.) 2. VIII.
Clistomorpha alberta Curr. 12. VI.
* didyma Lw. (C.C.) 10. VIII–IX.
* triangulifera Lw. (C.C.) 10, 12. VIII.
* **Winthemia** fumiferanae Toth. (C.C.) 10. V.
* quadripustulata Fab. (C.C.) 8, 10, 20. VI–VIII.
Parasite of many caterpillars, including Redbacked cutworm.
* rufopicta Big. (C.C.) 8, 10. VI.
* sinuata Rein. (C.C.) 10. VIII.
Meriana septentrionalis Curr. 2. IV.
* **Pateloa** silvatica A. & W. (C.C.) 10. V–VII.
* **Doryphorophaga** doryphorae Ry. (C.C.) Bred VIII.
Bred from potato beetle larvae at Edmonton, 1936.
* **Phorocera** claripennis Macq. (C.C.) 3, 10. VI.
* sternalis Coq. (C.C.) 10. VI.
* **Metaphyto** genalis Coq. (C.C.) 10. V.
* **Ernestia** flavicornis Br. (C.C.) 10, 18. VI–VII.
* frontalis Toth. (C.C.) V and VIII.
longicarina Toth. 18. VII.
* truncata Zett. ? (C.C.) 10. V–VI.
* **Nemorilla** floralis Fall. (C.C.) 3. V–VI.
* **Zenilla** affinis Fall. (C.C.) 10. VII.
* blanda O.S. (C.C.) 10. VIII.
* caesar Ald. (C.C.) 10. VIII.
* cheloniae Rand. (C.C.) 8, 10, 18. V–VII.
* confinis Fall. (C.C.) 12. VIII.
* eudryae Tns. (C.C.) 10. VIII.
* futilis O.S. (C.C.) 8, 10. VII.
reclinata A. & W. 18. VII.
submissa A. & W. 18. VIII.
* valens A. & W. (C.C.) 10, 20. VII–VIII.
* vulgaris Fall. (C.C.) 10. VIII–X.
Host records for nearly all of these species are given by Aldrich and Webber, Proc. U.S. Nat. Mus. vol. 63..1924.
Gonia aldrichi Toth. 3. IV.
Bred from Pale Western and Redbacked cutworms.
* breviforceps Toth. (C.C.) 2–4, 10, 19. V–VI.
* brevipulvilli Toth. (C.C.) 2. IV.
* fissiforceps Toth. (C.C.) 18–20. VII.
* frontosa Say (C.C.) 2, 10, 12. IV–VI.
* longiforceps Toth. (C.C.) 2, 3, 7. IV–VI.
An important parasite of Pale Western cutworms.
* longipulvilli Toth. (C.C.) 3, 10. IV–V.

TACHINIDAE—*continued.*

Peleteria aenea Stg. 6. VII.
alberta Curr. 19. VIII.
* anaxias Wlk. (C.C.) (? = apicalis) 4, 10, 18. VI–VIII.
angulata Curr. 19. VII–VIII.
* bryanti Curr. (C.C.) 3, 10, 12. VII–VIII.
* campestris Curr. (C.C.) 2, 3, 6, 10, 12, 15. VI–VIII.
* clara Curr. (C.C.) 2, 3, 6. VI–IX.
* confusa Curr. (C.C.) (? = apicalis) 10, 12. VII–IX.
cornuta Curr. 1, 6. VI–VII.
cornuticaudata Curr. 19. VIII–IX.
* eronis Curr. (C.C.) 2–4, 6. VI and VIII–IX.
* iterans Wlk. (C.C.) 2, 8, 10. V–VII.
phairi Curr. 19. VIII.
prompta Mg. 3. IX.
* **Hesperodinera** cinerea Tns. (C.C.) 6, 10. VII–VIII.
* **Admontia** pollinosa Curr. (F.M.) 10. VII.
* **Gibsonomyia** nigricosta Curr. (C.C.) 19, 20. VII.
Phyllomya alberta Curr. 12. VII.
Wagneria cinerosa Coq. 3. Bred.
distincta Curr. "Alberta".
* helymus Walk. (C.C.) 6, 8, 10. V–VII.
* sequax Will. (C.C.) 3, 19. V.
Bred from Army cutworm.
* **Œstrophasia** clausa Br. (F.M.) 10. V.
* **Sturmia** inquinata V. d. W. (C.C.) 6. Bred.
* phycioides Coq. (C.C.) 10. VII.
* ricinorum Tns. (C.C.) 6.
* **Achaetoneura** frenchii Will. (C.C.) 10. Bred.
Parasite of Forest Tent caterpillar.
malacosomae Curr. 3. VIII.
* **Exorista** mella Walk. (C.C.) 6, 8, 10, 18. VI–VIII.
Parasite of Forest Tent caterpillar.
* simulans Mg. (C.C.) 1, 8, 10, 12. VII–VIII.
* **Anachaetopsis** tortricis Coq. (C.C.) 10. IX.
* **Elodia** barbata Coq. (C.C.) 10, 18. VI–VIII.
* **Tachinomyia** panaetius Wlk. (C.C.) 3, 10. VI–VII and IX.
* variata Curr. (C.C.) 3, 8, 10. V–VII.
* **Allophocera** montana Sm. (C.C.) 2. IV.
Actia interrupta Curr. 19.
* **Siphona** cristata Fall. (C.C.) 10. VII.
* geniculata deG. (C.C.) 10. VI.
* **Aphria** ocypterata Tns. 10, 18, 20. VII.
* **Pelatachina** limata Coq. (C.C.) 8. VI.
* **Lixophaga** alberta Curr. (F.M.) 10. VII.
parva Tns. (C.C.) 10. VIII.
* variabilis Coq. ? (C.C.) 10. VII.
* **Laximasicera** sexualis Curr. (C.C.) 10, 12, 18. VI–VII.
* **Lydella** myoidea Desv. (C.C.) 10. VII–VIII.
* senilis Mg. (C.C.) 10, 12, 18. VII–VIII.
* **Acemya** tibialis Coq. (C.C.) 6. VI.

TACHINIDAE—*concluded.*

The following species are recorded in genera which are not included in Curran's "North American Diptera".

Apostrophus anthophilus Lw. 10. VII.
* **Euptilopareia** erucicola Coq. (C.C.) 20. VII.
Heteropterina nasoni Coq. 18. VIII.
Pseudotachinomyia Webberi Sm. 2. IV.

HIPPOBOSCIDAE. Louse flies

* **Ornithoctona** erythrocephala Lea. (J.B.) 12.
From Burrowing hawk.

* **Ornithomyia** fringillina Curt. (J.B.) 10, 12. VIII.
From chickadee, several species of sparrow, shrike, grosbeak, woodpecker.

* **Lynchia** botaweirorum Swenk (J.B.) 12.
From bittern.

* **Melophagus** ovinus L. (E.S.) 8, 10. VII.
Common on sheep around Edmonton. Probably occurs throughout the province where sheep are raised.

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